Chapter 4
Design

4-1. Waterstops

a. General. Waterstops are designed for hydraulic structures to withstand continuous water pressures for the life expectancy of the structure or for cyclic water levels and pressures in floodwalls and locks. Factors affecting design dimensions of metallic waterstops are largely traditional, stemming from experience rather than computation. The selection of nonmetallic waterstops is predicated to a great extent on hydrostatic considerations.

(1) Figure 4-1 shows the relation of material thickness and width requirements of polyvinyl chloride waterstops versus the height of hydrostatic head. For example in the graph, a concrete dam or lock that is designed to resist a 300,000-Pa (100 ft of water) head of hydrostatic pressure may require a PVC waterstop that is 250 mm (10 in.) wide and only 4 mm (0.16 in.) thick, whereas an 8-mm (0.32-in.)-thick PVC waterstop need only be 100 mm (4 in.) wide as shown in Figure 4-2. A wide range of PVC waterstop dimensions may be used to resist a single head pressure. This relationship represents an average value of hydrostatic pressure ratings for various sizes of PVC waterstops and is therefore relatively insensitive to small, subtle variations in the configuration of each individual waterstop. Thus, the graph is only valid for use as general guidance in the design and selection of PVC waterstops. Additional data concerning the material properties of PVC waterstops are presented by Hoff and Houston (1970).

(2) Certain waterstop sizes are used much more often than others. Whether through reference to previous designs or to peer usage, designers primarily specify 150-mm (6-in.) and 225-mm (9-in.)-wide waterstops. Thus, production, availability, and usage have become a self-perpetuating cycle in the design requirements of nonmetallic waterstops.

b. Conventional design considerations. Design engineers must consider several factors in selecting waterstop materials for possible use in their projects. Hydraulic structures require waterstops in all moving and nonmoving joints. The lateral movement anticipated for a joint wall determines the types of waterstop to be selected. The vertical movement anticipated for a joint will determine the shapes of the waterstop to be selected. The anticipated hydrostatic head of water will determine the thicknesses and the widths of the waterstop to be selected. The anticipated allowable water migration for a joint will determine both the types and shapes of the waterstop to be selected. The anticipated size of the joint opening will determine the configurations or profiles of the waterstop to be selected. Every structure and project is different and will be designed for their respective requirements.

c. Unconventional design considerations. Design engineers will consider several other factors in selecting waterstop materials for use in their structure. The performance of waterstop materials is affected by factors prior to their use in a concrete structure. The anticipated exposure of the waterstop material at a project prior to the time both edges are embedded in the concrete will affect the determination of selecting the thicknesses and widths of the waterstops. The anticipated types of materials handling procedures and techniques at a project will affect the determination of waterstop selection. Many materials may become worn, fatigued, or damaged from excessive handling and exposure to the environmental elements during construction. Rubber materials are more susceptible to ozone exposure than others. Polyvinyl chloride materials as well as rubber materials are susceptible to oils, solvents, and other chemicals.

4-2. Preformed Joint Seals

a. General. Preformed compression seals are designed primarily for nonhydraulic structures to prevent the introduction of unwanted and harmful particles from entering the joint and causing excessive compressional forces to be applied to the concrete surfaces during periods of expansion. It is the variation in joint conditions and joint material properties which influence the selection of one joint material over another. The compression seal is designed to be compressed and inserted into designed expansion and contraction joints of hardened concrete and remain in a compressed state throughout its life in the joint. Although preformed compression seals are installed with lubricant/adhesive for easy installation and bonding to the concrete surfaces, they are not designed to resist tensile forces, therefore the designer must be aware of the anticipated contraction that may occur in the concrete structure and particularly in the structural element. Preformed compression seals should always be compressed to a minimum of 15 percent of the material width. With the preformed compression seal always in compression, the sealant will change its shape as the width of the joint opening changes, therefore the designer must also be aware of the depth of the joint to allow the joint material to flex, normally downward into the joint.

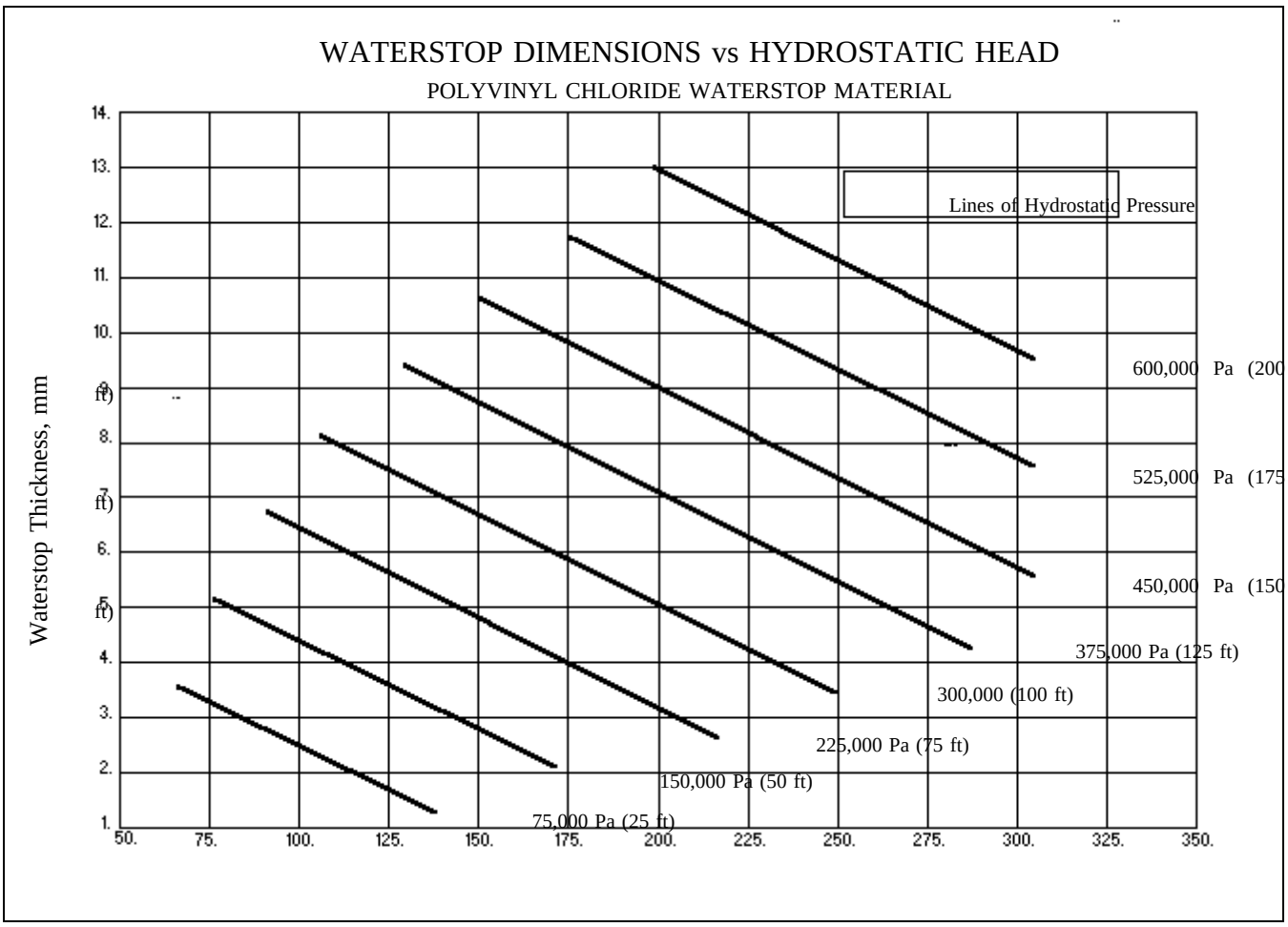

Figure 4-1. This graph shows the general relationship between polyvinyl chloride waterstop dimensions to the hydrostatic head pressure of water

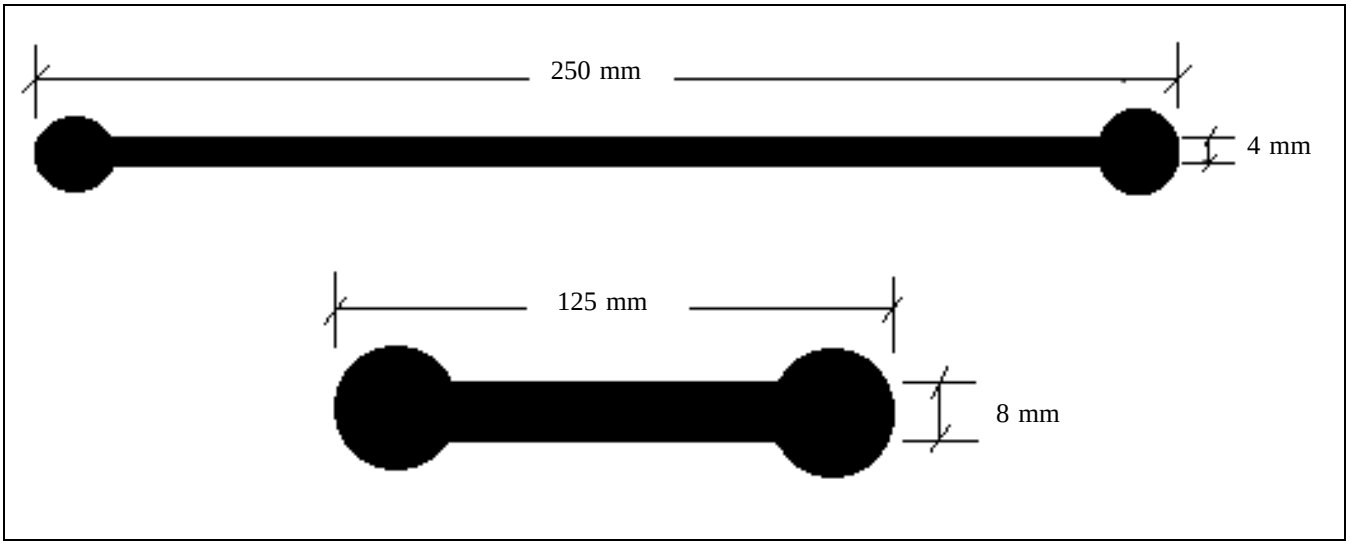

Figure 4-2. These two polyvinyl chloride waterstops of different dimensions may be used under identical 300,000-Pa (100 ft of water) hydrostatic head pressures as depicted in the graph shown in Figure 4-1

(1) Joint Dimensions for Preformed Compression Seals. These seals have a variety of different dimensions in width and height to cover a broad range of joint dimensions. The characteristics of the joint opening dictates the characteristics of the joint material to be specified. The initial dimensions of the joint opening, width and depth, plus the anticipated movement expected in the joint opening, narrowest to widest, from temperature variations and internal and external stresses applied to the concrete, specifies the characteristics of the joint opening. The general rule of thumb for the maximum amount of vertical movement of pavements and slabs within the joint opening is that it should not exceed 6 mm (1/4 in.).

(2) Preformed Compression-Seal Dimensions. Preformed compression seals are available in dozens of sizes and dimensions. The preformed compression seals may range in size dimensions from 8-mm (5/16-in.) widths and 16-mm (5/8-in.) heights to 150-mm (6-in.) widths and 140-mm (5.5-in.) heights. The preformed compression seals also have a wide variety of wall thicknesses and internal geometric designs and arrangements. In determining the correct compression seal for each individual project, the compression seal must be maintained in a compressed state at all times but not less than approximately 15-percent compression and the compression seal must also allow for approximately 40-percent joint movement based upon the uncompressed width of the compression seal (see Figure 4-3).

b. Design criteria. Design engineers must consider several factors in selecting preformed joint sealants and other joint materials for possible use. The anticipated movement, expansion, and contraction in a joint will determine the types of preformed joint material to be considered. The anticipated joint dimensions will determine the types and sizes of preformed joint material to be considered.

c. Material consideration. Design engineers must select the preformed joint material based on the joint dimensions, its width, depth, and length. The joint dimensions will determine the type and nominal size of the preformed joint material as designated by the manufacturers. The material consideration will also include the amount of lateral movement that may be anticipated during all applications, environmental conditions, and loadings. The anticipated joint movement will determine

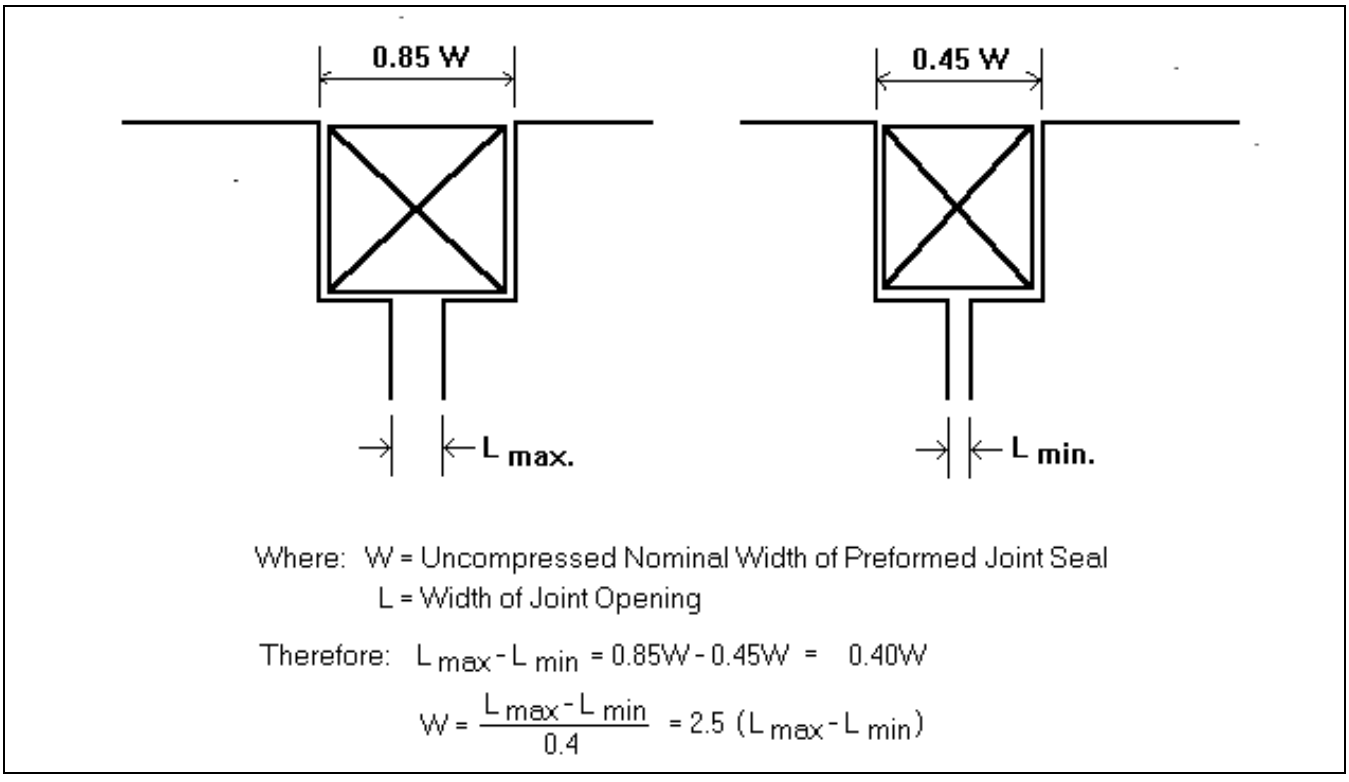

Figure 4-3. Determination of minimum size of compression seal

the type and nominal size of the preformed joint material required for the application. Many preformed joint materials such as compression seals are designed to be in a minimum of 15-percent compression at all times, therefore the designers must anticipate for the maximum movement as well as the minimum joint opening for that joint.