



Designation: D7492/D7492M – 16a (Reapproved 2024)

Standard Guide for Use of Drainage System Media with Waterproofing Systems¹

This standard is issued under the fixed designation D7492/D7492M; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This guide makes recommendations for the selection and application of prefabricated drainage media used in conjunction with waterproofing systems on horizontal and vertical surfaces. Drainage media considered include rigid and semi-rigid insulation boards and rigid materials including plastics. This guide considers drainage media as it relates to the performance of the waterproofing system, so its primary focus is draining water away from the membrane. This guide does not cover in detail other aspects or functions of drainage system performance such as efficiency of soil dewatering. The scope of this guide does not cover other drainage media including gravel and filter fabric systems that can be constructed. The scope of this guide does not cover drainage materials or drainage system designs used for vegetative roof systems. Vegetative roof systems require specialized designs.

1.2 The committee with jurisdiction over this standard is not aware of any other comparable standards published by other organizations.

1.3 The values stated in either SI units or inch-pound units are to be regarded separately as standard. The values stated in each system may not be exact equivalents; therefore, each system shall be used independently of the other. Combining values from the two systems may result in nonconformance with the standard.

1.4 This standard may involve hazardous materials, operations and equipment. *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.5 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recom-*

mendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.

2. Referenced Documents

2.1 ASTM Standards:²

[C165 Test Method for Measuring Compressive Properties of Thermal Insulations](#)

[C898/C898M Guide for Use of High Solids Content, Cold Liquid-Applied Elastomeric Waterproofing Membrane with Separate Wearing Course](#)

[C981 Guide for Design of Built-Up Bituminous Membrane Waterproofing Systems for Building Decks](#)

[C1471/C1471M Guide for the Use of High Solids Content Cold Liquid-Applied Elastomeric Waterproofing Membrane on Vertical Surfaces](#)

[D896 Practice for Resistance of Adhesive Bonds to Chemical Reagents](#)

[D1079 Terminology Relating to Roofing and Waterproofing](#)

[D2434 Test Methods for Measurement of Hydraulic Conductivity of Coarse-Grained Soils](#)

[D3273 Test Method for Resistance to Growth of Mold on the Surface of Interior Coatings in an Environmental Chamber](#)

[D3385 Test Method for Infiltration Rate of Soils in Field Using Double-Ring Infiltrometer](#)

[D4511 Test Method for Hydraulic Conductivity of Essentially Saturated Peat](#)

[D4630 Test Method for Determining Transmissivity and Storage Coefficient of Low-Permeability Rocks by In Situ Measurements Using the Constant Head Injection Test](#)

[D4716/D4716M Test Method for Determining the \(In-plane\) Flow Rate per Unit Width and Hydraulic Transmissivity of a Geosynthetic Using a Constant Head](#)

[D5898/D5898M Guide for Standard Details for Adhered Sheet Waterproofing](#)

[D6622/D6622M Guide for Application of Fully Adhered Hot-Applied Reinforced Waterproofing Systems](#)

[E154/E154M Test Methods for Water Vapor Retarders Used in Contact with Earth Under Concrete Slabs, on Walls, or as Ground Cover](#)

¹ This guide is under the jurisdiction of ASTM Committee D08 on Roofing and Waterproofing and is the direct responsibility of Subcommittee D08.22 on Waterproofing and Dampproofing Systems.

Current edition approved Jan. 1, 2024. Published January 2024. Originally approved in 2011. Last previous edition approved in 2016 as D7492/D7492M – 16a. DOI: 10.1520/D7492_D7492M-16AR24.

² For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

3. Terminology

3.1 Refer to Terminology **D1079** for definitions of terms used in this guide.

4. Summary of Practice

4.1 This guide describes a method to estimate the amount of water a drainage system may need to carry. The guide also offers descriptions of the various drainage systems in existence today along with suggestions on how different building situations will require different performance characteristics from the drainage medium chosen. Items to be aware of during the installation of drainage systems are also covered along with illustrations of typical drainage systems.

5. Significance and Use

5.1 This guide provides information and guidelines for the selection and installation of drainage systems media that are in conjunction with waterproofing systems. This guide is intended to be used in conjunction with Guides **C898/C898M**, **C981**, **C1471/C1471M**, **D5898/D5898M**, and **D6622/D6622M** and to provide guidelines for the total waterproofing and drainage system.

6. General

6.1 In selecting a drainage medium for use with waterproofing, consideration should be given to the design of the waterproofing system. In particular orientation of the system, attachment recommendations, connections to interior and exterior drainage systems, and external loads applied to the system. Additional considerations include the materials and construction over the drainage medium, installation recommendations, durability, and penetrations and joints. (See **Figs. 1-3**.) In all designs, the potential slip planes should be considered.

6.2 *Compatibility*—It is essential that all components and contiguous elements of the waterproofing system are compatible and that the design of the system’s waterproofing and drainage is coordinated to form an integrated waterproofing system.

6.3 *Basic Components*—The various types of drainage media available are outlined in Section **12** of this guide and all

consist of one or more of the following basic components. The basic components of typical drainage medium are a mounting surface that is placed against the waterproofing membrane to prevent embedment of the media, a porous core that provides a drainage path, and a filter surface, often a fabric bonded over the porous core to prevent clogging of the drainage paths. Fibrous and foam drainage media are homogeneous materials that are sufficiently dense that they can be placed directly against the waterproofing membrane. However, fibrous and foam media may not function properly in horizontal or nearly horizontal (<30°) orientations. Other foam boards merely provide periodic grooves creating paths to drain water away from the waterproofed surface. Where appropriate, a protection board should be installed between the waterproofing and drainage media to reduce embedment of drainage media into the waterproofing.

6.4 The drainage media selection should include a consideration of the forces that will be placed on it, such as backfill pressure, gravity loads, and shear loads both initially and over the expected useful life of the assembly.

6.5 The construction of drainage media should be considered relative to the strength and protection of the waterproofing membrane. The bearing surface of drainage media should place no sharp edges against the waterproofing membrane, which could puncture, abrade the membrane, or imprint itself in the membrane. The filter fabric and its bond to the drainage medium core should resist impact, compressive, and shear loads imposed by backfilling and compaction, and temporary and permanent construction loads.

6.6 The drainage media should always be placed next to the waterproofing. This location minimizes the hydrostatic head on top of the waterproofing. If insulation is required the insulation shall be specified to handle the environment that is present outside the drainage media and waterproofing membrane. If the insulation is porous, the drainage media must allow the porous insulation to drain any water accumulated during construction or during its service on the wall into either the drainage media or the footing drain tile system. A non-porous insulation is any insulation with closed cells that prevent water from flowing in or out, for example extruded polystyrene foam or polystyrene foam bead boards. A porous insulation is any insulation that has open channels that easily allow water to enter and leave the insulation such as rigid fiberglass boards with a perm rating of 4.6 Darcy (k, mm/s) or more (see **X1.1.3**).

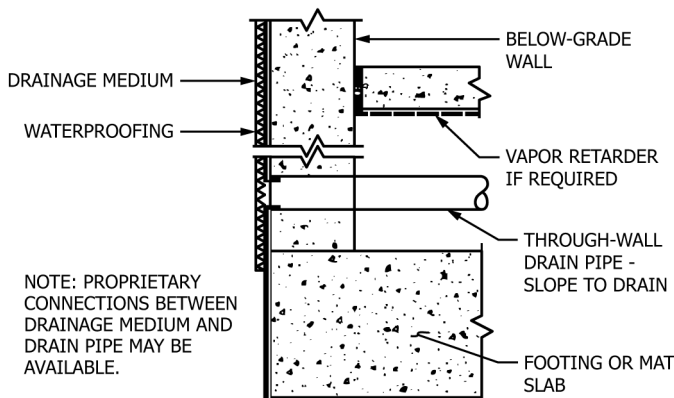
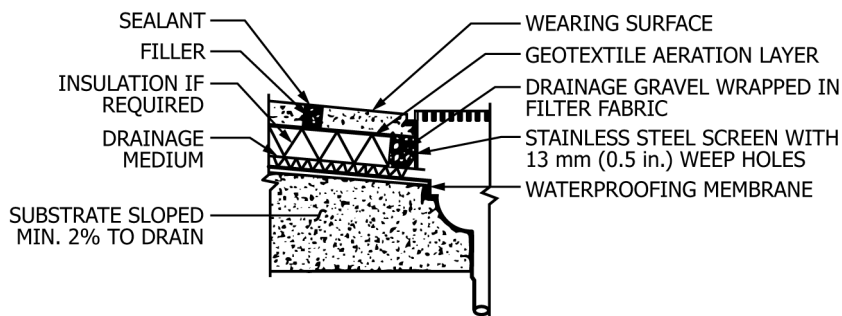


FIG. 1 Drainage at Lot Line Below-Grade Wall

7. Drainage Capacity

7.1 *General*—The drainage capacity is the volume of water that passes through drainage media in a specified direction under a known hydraulic gradient. The two major drainage capacities of interest are the in-plane and through-the-face drainage capacities. The orientation of the media and any slope of the substrate will have a major effect on the drainage capacity.

7.1.1 *Through-the-Face Drainage*—Through-the-face drainage is the flow or seepage of water perpendicular to the longitudinal axis of the drainage media. When media are installed in a horizontal orientation, through-the-face drainage



NOTE 1—Or slotted drains with 1/2 in. slots.

FIG. 2 Drain in Plaza with Solid Surfacing

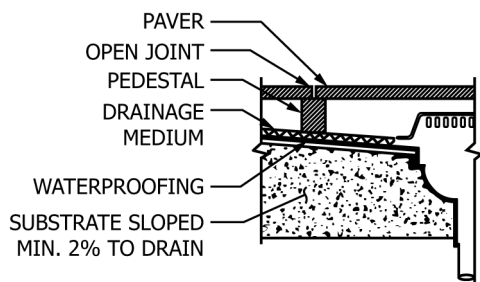


FIG. 3 Drain in Plaza with Paver and Pedestal Surfacing

may occur due to cracks, joints, or other openings in the material(s) placed atop the media or due to the normal permeability of the material(s) such as soil. Through-the-face drainage capacity is critical to the drainage system's efficiency at removing water from the overburden, which may affect the performance and durability of the overburden, but is less relevant to waterproofing membrane performance. In applications where removal of water from the overburden is an expected function of the drainage media, the filter surface, whether fabric or the base material, should have adequate porosity so as not to restrict drainage through the face of the media.

7.1.2 In-plane Drainage—In-plane drainage is the flow or seepage of water within and along the plane of the drainage media and refers to the ability of the drainage media to remove whatever water makes it through the overburden and into the drainage media. In-plane drainage helps the performance of most membrane waterproofing systems by minimizing the exposure of the membrane to hydrostatic pressure. In horizontal orientations, the hydraulic gradient will be relatively low. Therefore, the drainage paths or pores in the media should be relatively large to ensure the media does not hold water due to surface tension and capillary forces.

7.1.2.1 To determine the drainage capacity needed, the designer should be familiar with the climate, terrain, adjacent buildings, and structures that could redirect rain water or run off onto the area that has to be drained, whether there is soil overburden on the drainage media, etc. **Appendix X1** contains methods that could be used to calculate the capacity needed for the drainage system. In no way does **Appendix X1** contain all the different methods for calculating the capacity needed by a drainage system; other methods may exist that are not covered in **Appendix X1**.

7.1.3 Resistance to Clogging—Drainage media should resist clogging or silting of the media filter or other openings. The function of the filter surface is to prevent excess soil or other materials from entering the drainage media and impeding in-plane drainage. In applications where removal of water from the overburden (through-the-face drainage) is an expected function of the drainage media, avoiding clogging of the filter surface itself is just as important. Selection of the media to resist clogging should be based on the particle-size distribution of the material(s) placed adjacent to the filter media. If the filter opening size is large relative to the majority of adjacent particles, the adjacent particles will pass through the filter media and may, in time, clog the media. A correctly selected filter media should permit some fine particles to pass through the face of the media but retain a layer of larger particles at its surface until a filter cake is established. The fine particles within the media will eventually be flushed from the media. As for determining which fabric should be used, there are a number of resources that may be used if the particle-size distribution is known. Several geotextile manufacturers have brochures and spec data sheets for different types of fabrics that contain information on how to choose the right geotextile for the given situation. Another fabric may be needed to handle particular soils or situations with fine laden overburden. Recent civil engineering handbooks (see **Note 1**) have sections devoted to the selection of geotextiles for filtration and water drainage among other topics. Some handbooks on drainage system design recommend designing the drainage system assuming the filter fabric is 50 % clogged.

7.1.4 Long-Term Performance—The materials used for drainage media must be capable of surviving the environment in which they are placed for at least the life of the waterproofing system. The physical properties of the media that relate to drainage capacity, such as compressive strength, shear strength, resistance to biological deterioration, and freeze-thaw resistance must be sustained throughout the service life of the media.

7.1.5 Another performance issue arises when installing drainage media on “vegetative roof system” or garden patio situations. Consideration must be given on how the drainage media will either stop root penetration or how the roots from large plants and small trees will affect the performance of the drainage media. How this is accomplished along with other design criteria necessary for a “vegetative roof system” is beyond the scope of this guide. See **Note 1**.

NOTE 1—The footnoted books on civil engineering^{3,4} and other relevant books may be found on websites such as Amazon.com and Barnesandnoble.com.

7.1.6 *Interfaces To Other Drainage Systems*—The selection of drainage media must take into consideration the joining of the installed media to other adjacent drainage systems that can be located inside (lagging walls, Fig. 1) and outside of a building or foundation. For a horizontal orientation, consideration must be given to adequately connecting the drainage media to vertically oriented drainage media. For a vertical application, consideration must be given to the connection with the drainage system at the base of the media, usually a perimeter drain system.

8. Physical Properties

8.1 *General*—Drainage media used in conjunction with a liquid-applied waterproofing system should have certain physical properties to provide some level of confidence that the drainage media will perform as stated throughout its required service life. Properties that are considered in this guide include drainage capacity (discussed in Section 7), compressive strength, flexural strength, puncture resistance, edge strength, and embrittlement. Many ASTM standards are available to test these properties and the ASTM tests will vary depending on the drainage medium being tested. Test Methods D4716/D4716M and C165 are just two of the many test methods referenced in product literature.

8.2 *Compressive Strength*—The drainage media should have sufficient compressive strength to support weight of construction over the media as well as any external live loads placed upon it after installation. For horizontal orientations, these loads are installed atop the drainage media. For vertical orientations, the loads acting on the drainage media are primarily soil pressure from backfill. Installations against lagging may also include the initial load of the cast-in-place concrete. Temporary loads, both gravity and shear and abuse during construction, should also be considered. The porous portion of the drainage media should have sufficient long-term compressive strength to prevent excessive deformation or collapse of the media due to crushing, buckling, or creep, which would constrict or close the drainage paths within the media.

8.3 *Flexural Properties*—The drainage media should have sufficient flexural strength or flexibility to withstand or accommodate bending loads that occur in normal handling during installation. The material should also be capable of bridging or conforming to joints and uneven areas without cracking or breaking.

8.4 *Puncture Resistance*—Drainage media should be able to withstand possible damaging effects of subsequent construction work before being protected by other waterproofing system components. Damage in horizontal orientations could be punctured by reinforcing rod chairs and reinforcing rods

used in the wearing course or from construction vehicle and foot traffic. Roots and sharp objects in the backfill can cause puncture damage in vertical orientations.

8.5 *Edge Strength*—In vertical orientations, the filter media must be capable of withstanding the vertical shear loads that occur as the backfill settles. When drainage media is installed over a smooth membrane, shear load from backfill consolidation can be transmitted to the bottom edge of the drainage media, which must withstand these loads without crushing. If soils are designed and compacted correctly, the drainage media should not experience this effect.

9. Materials

9.1 *General*—Drainage media must be compatible with the waterproofing system and capable of withstanding cyclical immersion and specified to be able to resist any chemical attacks from any leachates found to be in the drainage flow. In horizontal orientations, leachates can include salt solutions, petroleum distillates, fertilizers, and chemical residues from the waterproofing system's primers and adhesives. In vertical orientations, leachates can include soil salts, petroleum distillates, and chemical residues from the waterproofing system and any surface treatment placed over the above-grade portion of the drainage material. ASTM tests such as Test Methods D3273, D896, and E154/E154M, and others, can be used to evaluate long-term performance of various drainage media. Again the type of drainage media used and the chemical composition of the drainage will determine the appropriate ASTM test method.

9.2 Materials used to hold drainage media in place, whether an adhesive or mechanical fasteners, must maintain their holding strength for such a period as required for external forces acting on the filter media to reach equilibrium. The materials used to hold the filter media in place relative to the waterproofing membrane must retain this strength when subjected to chemical attack from trace chemical in the drainage flow.

10. Attachment Techniques

10.1 *General*—Drainage media may need some form of attachment to the substrate. If adequate attachment is not achieved, the drainage system media may be damaged or dislodged, or both, by soil settlement or frost heaving. The attachment method should be coordinated with the expected soil compaction methods and settlement, and the potential for frost heaving where applicable. Attachment of drainage media may be by adhesives, suitable mechanical fasteners, or by loading forces of adjacent material. With most waterproofing membranes, it is not advisable to penetrate the waterproofing with mechanical fasteners below grade; however, with some swelling-type waterproofing systems that are intended to be mechanically attached, similar attachment may be used to attach the drainage media. If the media require installation according to prescribed requirements for orientation, care should be taken to follow the drainage media manufacturer's instructions regarding installation of the media.

10.2 *Adhesives:*

³ *Civil Engineering Handbook*, 2nd edition, Liew, R. J. V. and Chen, W. F., editors, August 2002.

⁴ *Standard Handbook for Civil Engineers*, Richards, J. T., Merritt, F. S., and Loftin, M. K., editors, Dec 2003.

10.2.1 *General*—Adhesives can be used to hold drainage media in place relative to the waterproofing membrane, often until additional courses are installed atop the media. The adhesive must be applied over an area sufficient to provide the required bonding strength.

10.2.2 *Compatibility*—The cured adhesive must be compatible with the waterproofing material and the drainage medium. Solvent in the adhesive must also be compatible with the waterproofing as solvents can damage some waterproofing membranes.

10.2.3 *Properties*—Adhesives for drainage media must have sufficient tack upon initial installation to firmly hold the media in place until cure of the adhesive is complete. Wind uplift forces can loosen the media in both horizontal and vertical orientations if the initial bond forces are not sufficient. The cured adhesive must have sufficient strength to hold the media in place during subsequent construction operations and for vertical orientations to resist any shear forces inadvertently created as the backfill settles. Most manufacturers will warrant their anchorage designs only for adequate support of their drainage media. Any forces created by backfill must be carefully considered and minimized.

10.2.4 *Cure Time*—The cure time of the adhesive should be taken into consideration in scheduling subsequent construction tasks.

10.3 *Mechanical Fasteners:*

10.3.1 *General*—Mechanical fasteners that penetrate the waterproofing membrane should be avoided. Mechanical fasteners should be stainless steel to prevent corrosion from completely destroying the fastener leaving a hole into the substrate.

10.3.1.1 *Effect of Fastener on Waterproofing*—The area around the fastener may require additional treatment to maintain the integrity of the waterproofing membrane. The manufacturer’s literature for the membrane should be consulted to ensure an appropriate fastener is used.

10.3.1.2 *Mechanical Fasteners Can Damage Drainage Media*—If installed too tightly, drainage media can be compressed, restricting drainage. If the fastener is loose, the media can separate from the membrane, permitting debris to fill the space and possibly result in damage to the membrane or the drainage media. Loose attachments can also fail completely

when the waterproofing system dead loads or live loads are applied to the system.

10.3.1.3 *Effect of Fastener on Substrate*—The mechanical fasteners that are embedded into the substrate should be avoided. Mechanical fasteners that are forced into the substrate can cause spalling which may extend underneath the waterproofed surface.

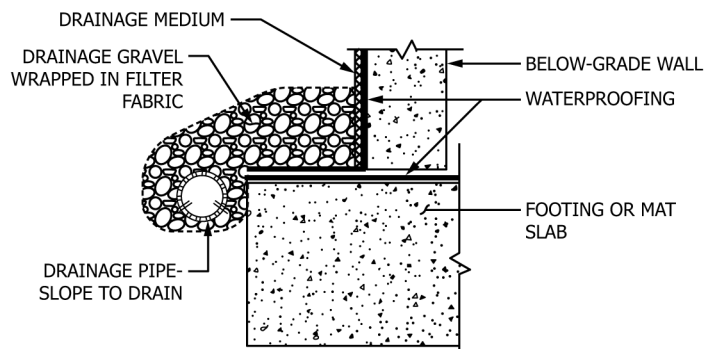
10.3.1.4 *Fastener Geometry*—Mechanical fasteners should be selected for their ability to not interfere with the integrity of the waterproofing system. The fasteners should sit flush with the surface of the drainage media if possible to avoid providing a point of extreme loading on the fastener from external loads. Fasteners that are not flush with the surface of the drainage material can be knocked out by subsequent backfilling, compaction and other construction processes.

11. **Installation Details**

11.1 *General*—The waterproofing system designer should provide generic details similar to those contained in the construction documents for properties required of the drainage media and including typical conditions, special conditions, and changes in plane, terminations, penetrations, and connections to other systems (Figs. 1-4). Proprietary systems have standard details that may be included in the construction documents, but should always be submitted during the approval process via submittals. Installation of drainage media should be in accordance with the manufacturer’s written specifications and installation instructions.

11.2 *Laps*—Continuity of both the drainage path and the filter fabric should be maintained at side laps and end laps in the drainage medium. Some products include a fabric selvedge at the side laps but not the end laps; in such cases an additional strip of filter fabric, of width no less than twice the width of the typical selvedge, should be installed to cover the end laps to prevent soil or debris from entering and clogging the drainage medium.

11.3 *Cutting*—Cutting drainage media to fit around penetrations and substrate protuberances should be done in such a manner as to not damage the core material. Care should be exercised to ensure that the media cut edges do not provide a path for soil or debris to enter and clog the drainage medium.



NOTE: PROPRIETARY CONNECTIONS BETWEEN DRAINAGE MEDIUM AND DRAIN PIPE MAY BE AVAILABLE.

FIG. 4 Drainage at Below-Grade Wall

For drainage media that drain only on one side and do not allow water to flow between the sides of the drainage medium, it may also be important to detail cut edges to avoid providing a path for drainage flow to pass between the drainage medium and the waterproofing membrane. Some products require overlapping of the filter fabric at junctures of the media, so care should be exercised when cutting the media to ensure sufficient filter fabric remains attached to achieve the correct overlap with adjoining material.

11.4 Conformity—The waterproofed substrate is often not completely flat, necessitating tailoring drainage media to conform to curved or irregular surfaces. In addition, some products packaged in rolls have “memory” and tend to curl up at the edges, thereby interfering with conformance to the substrate. Some products are sufficiently pliable that they deform easily to conform to the membranes surface. Care should be exercised when deforming the media to conform to an uneven surface, to ensure the core material and filter fabric are not damaged or separated. It is acceptable practice with some media to partially cut through outer layers of the media to make it more pliable.

11.5 Interface with Adjacent Media—Use of drainage media on a complex structure will require the connection of drainage media of various orientations; that is, horizontal-to-vertical, vertical-to-vertical at corners, horizontal-to-horizontal at penetrations, and sloped media to both horizontally and vertically oriented media. The most important connection is at penetrations in horizontal orientations, and from sloped media to both horizontally and vertically oriented media. Another important connection is from drainage media to auxiliary drainage systems such as horizontal drains and perimeter foundations drains. See [Figs. 1-4](#).

11.6 Interface Horizontal-to-Vertical—To ensure that flow from horizontally oriented media to vertically oriented media is not impeded, appropriate connection at the horizontal-vertical juncture is necessary. Some drainage media have an impervious backing that is placed against the waterproofing membrane. The horizontal and vertical juncture should be cut on a bias to ensure the drainage path from horizontal media is directly connected to the drainage path of vertical media. Filter fabric should be placed at the juncture to ensure the area does not become clogged during subsequent construction operations or from soil particles.

11.7 Interface Vertical-to-Vertical—In vertical orientations of drainage media, the media will be joined at inside and outside corners. Ideally in both installations, drainage media should be cut so that a continuous drainage path exists between the vertical media. Filter cloth should overlap the adjacent media.

11.8 Interface to a Perimeter Drain-Pipe System—Drainage media will only function properly if connected to an auxiliary drainage system that provides a means for removal of the water from the drainage cores of the media. In nearly all installations, the auxiliary drainage system is a perimeter foundation drain system. While the vast majority of drainage pipes are round, other geometries such as rectangles and triangles are occasionally encountered. See [Fig. 4](#).

11.8.1 The drainage pipe when placed off the footing should be placed on 4 to 6 in. of gravel and surrounded on its sides with a minimum of 6 in. of gravel, unless the vertical face of the footing is too close to one side. If water is expected to rise up from the soil rather than drain from the surface, gravel underneath the tile should also be increased to a minimum of 6 in. On top of the tile the gravel should be placed at a minimum depth of 8 to 12 in. and 8 to 12 in. up the face of vertically oriented drainage media. The gravel should be covered with filter cloth to prevent clogging. The perimeter drain should have a positive slope to a sump or daylight

11.8.2 If the drain pipe must be placed on the footing, the top of the pipe should be no higher than the bottom of the interior floor slab. Gravel should be placed over the pipe and extend a minimum 8 to 12 in. up the face of the drainage material.

11.9 Expansion joints should be accommodated, not bridged.

11.10 Exposure Time—Most drainage media and especially filter fabrics are not intended for long-term exposure to sunlight. Overburden or temporary protection should be installed in a timely manner to avoid exceeding the maximum exposure time recommended by the manufacturer.

11.11 Terminations—Terminations such as the top of a foundation wall at grade, or rising walls at the perimeter of a plaza, should be detailed to prevent clogging and to avoid leaving the drainage media exposed. Examples of such detailing include wrapping the filter fabric at the end of the drainage media around onto the underside, or extending the filter fabric up behind the counterflashing.

12. Products

12.1 Available Products—Commonly available drainage media can be classified as plastic mats or insulation boards. This section provides a general description of these products and their properties.

12.2 Plastic Mats—Generally plastic mat drainage media consist of a molded or woven plastic core covered on one or both faces with filter fabric. The fabric filters, the water, and the plastic core provides open pathways for the water to flow to the drain pipe. Plastic core designs include egg carton/dimple, waffle, and thick cross-woven rib styles. Some styles have filter fabric on one face and a solid backing for the other. Filter fabrics can consist of needle punched non-woven fabrics, woven fabrics, and heat bonded fabrics. Generally all these fabrics consist of polyolefin fibers constructed into a fabric by one of the processes described above. Needle punched and heat bonded fabrics consist of fibers laid down in a somewhat random pattern and then bonded together by forcing entanglements via needles pushed through the fabric or passed over a heated surface that melts fiber intersections to create a fabric. Woven fabrics are made like cloth on loom-like machines. All these fabrics come in different strengths, thicknesses, and equivalent pore opening sizes and any and all can be found surrounding the various cores described above. The fabric needs to be strong enough not to rip under the loads experienced by the drainage media and at the same time have pore