Designation: D 6088 – 97 (Reapproved 2002)

Standard Practice for Installation of Geocomposite Pavement Drains[1]

This standard is issued under the fixed designation D 6088; 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 practice covers recommendations and identifies pertinent areas of consideration for the installation of buried geocomposite drains used for highway edgedrains, underdrains, or other pavement drainage applications. These recommendations are intended as guidelines for developing a satisfactory construction and installation method to minimize installation-caused deformation or damage and to provide long-term performance of these products. It is also intended as a guideline for ensuring a stable underground environment for these materials under a wide range of service conditions. Because of the numerous and diverse product designs available and the inherent variability of natural ground conditions, achieving satisfactory performance of any one product may require review by the engineer and modification to provisions contained herein to meet specific project requirements.

1.2 The scope of this practice necessarily excludes product performance criteria such as compressibility in any plane, flow capacity, inlet capacity, or geotextile selection and use. It is, therefore, incumbent upon the product manufacturer, specifier, and project engineer to verify that the product specified for an intended application, when installed according to procedures outlined in this practice, will provide satisfactory long term performance according to criteria established by the owner for that application. A commentary of product performance and installation factors important in achieving a satisfactory installation is included in Appendix X1.

1.3 The values stated in SI units are to be regarded as the standard. The inch-pound units given in parentheses are for information only.

1.4 *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 and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*

D 8 Terminology Relating to Materials for Roads and Pavements[2]
D 420 Guide to Site Characterization for Engineering, Design, and Construction Purposes[3]
D 653 Terminology Relating to Soil, Rock, and Contained Fluids[3]
D 698 Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12 400 ft - lbf/ft^3, 600 kn-n/n^3)[3]
D 2321 Practice for Underground Installation of Thermoplastic Pipe for Sewers and Other Gravity-Flow Applications[4]
D 2487 Classification of Soils for Engineering Purposes (Unified Soil Classification System)[3]
D 2488 Practice for Description and Identification of Soils (Visual-Manual Procedure)[3]
D 3839 Practice for Installation of "Fiberglass" (Glass-Fiber Reinforced) Thermosetting Resin Pipe[4]
D 4318 Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils[3]
D 4439 Terminology for Geosynthetics[5]
F 412 Terminology Relating to Plastic Piping Systems[4]

3. Terminology

3.1 *Definitions:*

3.1.1 Definitions used in this practice are in accordance with Terminologies F 412, D 8, and D 653 unless otherwise indicated.

3.2 *Definitions:*

3.2.1 *aggregate*—a granular material of mineral composition such as sand, gravel, shell, slag or crushed stone (see Terminology D 8).

3.2.2 *dense-graded aggregate*—an aggregate that has a particle size distribution such that, when it is compacted, the resulting voids between the aggregate particles, expressed as a percentage of the total space occupied by the material, are relatively small.

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[1] This practice is under the jurisdiction of ASTM Committee D35 on Geosynthetics and is the direct responsibility of Subcommittee D35.03 on Permeability and Filtration.

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[2] *Annual Book of ASTM Standards*, Vol 04.03.
[3] *Annual Book of ASTM Standards*, Vol 04.08.
[4] *Annual Book of ASTM Standards*, Vol 08.04.
[5] *Annual Book of ASTM Standards*, Vol 04.13.

3.2.3 *engineer*—the individual in responsible charge of the work or his duly recognized or authorized representative.

3.2.4 *geocomposite*, *n*—a product fabricated from any combination of geosynthetics with geotechnical materials or other synthetics which is used in a geotechnical application.

3.2.5 *geosynthetic*, *n*—a planar product manufactured from polymeric material used with foundation, soil, rock, earth, or any other geotechnical engineering related material as an integral part of a man-made project, structure or system. (See Terminology D 4439.)

3.2.6 *geotextile*, *n*—any permeable geosynthetic comprised solely of textiles. (See Terminology D 4439.)

3.2.7 *manufactured aggregates*—aggregates such as slag that are products or byproducts of a manufacturing process, or natural aggregates that are reduced to their final form by a manufacturing process such as crushing.

3.3 *open-graded aggregate*—an aggregate that has a particle size distribution such that, when it is compacted, the voids between the aggregate particles, expressed as a percentage of the total space occupied by the material, remain relatively large.

3.4 *optimum moisture content*—The moisture content of soil at which its maximum density is obtained (see Test Methods D 698).

3.5 *permeability*, *n*—the rate of flow of a liquid under a differential pressure through a material.

3.6 *permeability*, *n*—of geotextiles, hydraulic conductivity.

3.7 *permittivity, (γ), (T^{-1})*, *n*—geotextiles, the volumetric flow rate of water per unit cross sectional area per unit head under laminar flow conditions, in the normal direction through a geotextile. (See Terminology D 4439.)

3.8 *processed aggregates*—aggregates that are screened, washed, mixed, or blended to produce a specific particle size distribution.

3.9 *standard proctor density*—the maximum dry unit weight of soil compacted at optimum moisture content, as obtained by laboratory test in accordance with Test Methods D 698.

4. Summary of Practice

4.1 This practice outlines the key installation criteria that should be addressed for proper installation and maximum performance of geocomposite edge or underdrain materials, or both. The engineer should review the specifics of the system. Geocomposite drainage materials in this practice are products fabricated from any combination of geosynthetics and used as edgedrains or underdrains for paved surfaces such as highways, streets, parking areas, and similar applications. Trench excavation, the depth of drain placement, type of backfill, backfill placement, compaction of backfill, product fittings and equipment used during installation are addressed in this practice.

5. Significance and Use

5.1 This practice is intended to provide installation guidance for designers, specifiers, installation contractors, regulatory agencies, owners, and inspectors who are involved in the planning and installation of geocomposite pavement edgedrains and underdrains. As with any standard practice, modification may be required for specific project conditions or for special local or regional conditions. Fig. 1 shows the proper horizontal alignment of the drain based on various trench conditions outlined in 9.2, and the vertical depth of placement of the drain needed for a geocomposite edge drain to function most effectively as both a collector and conduit.

5.2 Fig. 2 shows the typical type and arrangement of equipment used to install geocomposite highway edgedrains. The combination of these recommended installation conditions, techniques, and equipment are critical to the satisfactory long term performance of these products.

6. Inspection, Handling, and Storage

6.1 *Inspection*—Upon receipt, inspect each shipment of pipe, geocomposite, and fittings for conformance to product specifications and contract documents, and check for damage. The engineer should reject damaged, deformed, crushed, or nonconforming material and remove from the project.

6.2 *Handling and Storage*—Handle and store the material in such a way as to prevent damage. Protect all geotextile materials from sunlight exposure until immediately before installation.

7. Backfill Materials

7.1 Backfill material selection and placement method should be based primarily on achieving adequate compaction without damaging the drainage panel, while also achieving intimate contact with the trench wall or backfill material, or both. Excessive compaction efforts may damage geocomposite drainage materials and should be avoided. Skid vibratory compactors that are used in the trench adjacent to the panel, can damage the panel if not properly aligned and operated. Free flowing materials, such as pea size crushed stone and dry or moist sand is suitable in most cases and should be placed in 150 mm (6 in.) lifts. Placement of sand backfill can be done by flushing or puddling, but this should be used only when approved by the engineer. Post-installation settlement in the backfill will occur if the backfill is not properly densified. Significant settlement can cause shoulder drop-off settlement and other pavement distress problems and structure damage to the panels. Permeability of the backfill material must also be considered; open-graded backfills will promote higher ground water flow to the drainage system, will provide a larger sink for collecting water, and will also provide additional flow area during maximum rainfall events. Soil migration from adjacent soils (trench walls) must be considered when using open graded backfills.

7.2 *Classification*—Materials for potential use as embedment and backfill of various components of subsurface drainage systems are classified in Fig. 3. They include natural, manufactured, and processed aggregates and the soil types classified according to Classification D 2487. Processed materials produced for highway construction (including coarse aggregate, base, subbase, and surface course materials) when used for embedment and backfill, should be classified in accordance with this section and Fig. 3 according to particle size, shape, and gradation.

7.3 *Installation and Use*—Fig. 4 provides recommendations on installation and use based on class of soil or aggregates.

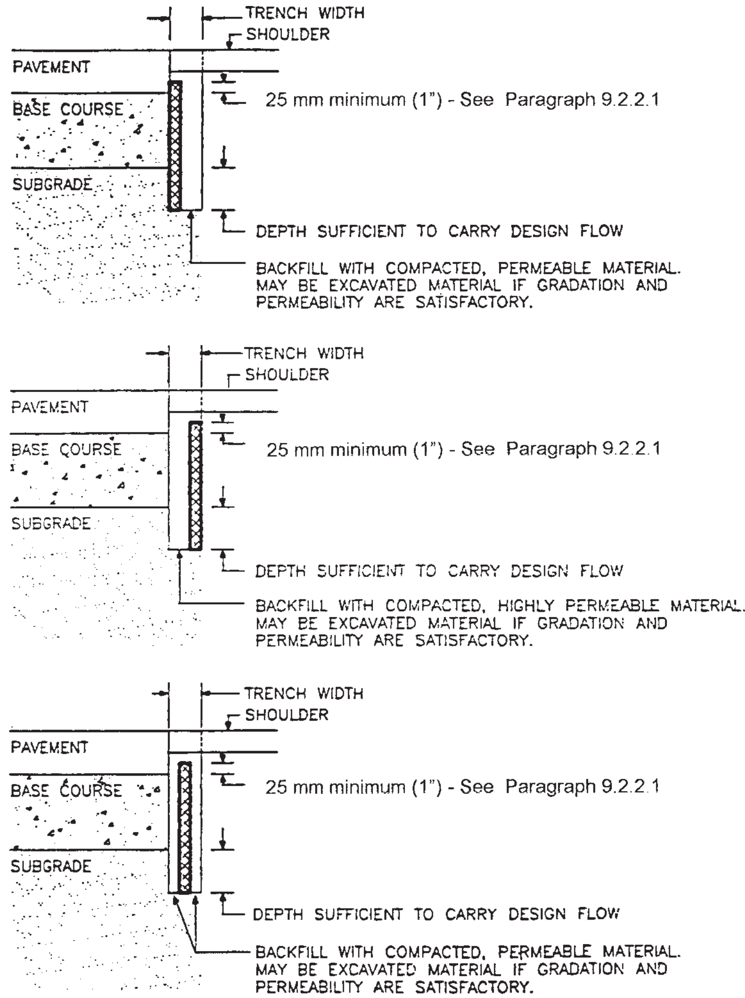


FIG. 1 Typical Type and Arrangement of Drain

7.3.1 *Use of Class III Soils and Aggregates*—These materials may be used as recommended in Fig. 4, provided the permeability of the material is adequate and approved by the engineer.

7.3.2 *Use of Class IVA, Class IVB and Class V Soils and Frozen Materials*—These materials are not recommended for backfill and shall be excluded from the final backfill except where approved by the engineer.

7.4 *Description of Backfill Material*—Sections 7.4.1 through 7.4.5 describe characteristics of materials recommended for backfill. Consideration must be given to the potential for migration of fines from adjacent materials into the backfill (see appendix).

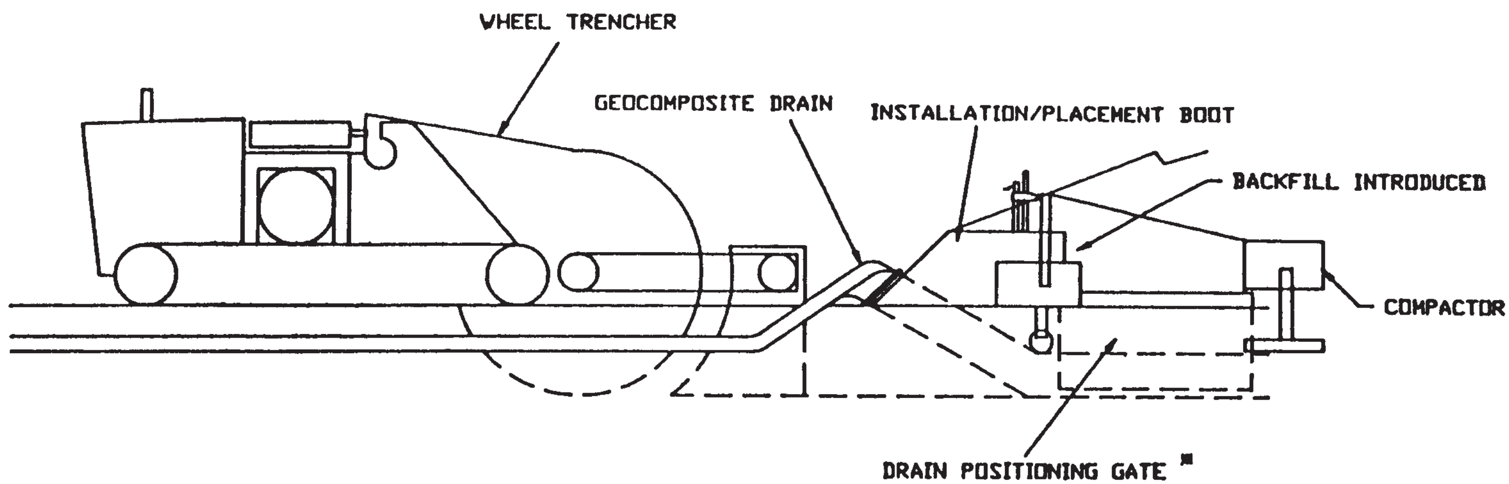
7.4.1 *Class IA Materials*—Class IA materials provide maximum stability and support for a given density due to angular interlock of particles. With minimum effort, these materials can be installed in relatively high densities over a wide range of moisture contents. The high permeability of Class IA materials can aid in the performance of these drainage systems. However, careful consideration must be given to the potential for migration of fines from adjacent materials into the open-graded Class IA materials.

7.4.2 *Class IB Materials*—Class IB materials are processed by mixing Class IA and natural or processed sands to produce a particle size distribution that minimizes migration from adjacent materials that contain fines. They are more densely graded than Class IA materials and thus require more compactive effort to achieve the minimum density specified. When properly compacted, Class IB materials offer high stiffness and strength. Class IB materials may be relatively free draining, but the amount and gradation of fines must be controlled.

7.4.3 *Class II Materials*—Class II materials provide a relatively high level of structural support. Open graded groups may allow migration and gradations shall be checked for compatibility with adjacent material. Typically, Class II materials consist of rounded particles and are less stable than angular materials unless they are confined and compacted.

7.4.4 *Class III Materials*—Class III materials provide less support for a given density than Class I or Class II materials. Higher levels of compactive effort may be required unless moisture content is carefully controlled. These materials provide satisfactory levels of structural support once proper density is achieved. Fines content should be minimized for optimum permeability.

7.4.5 *Class IVA Materials*—Class IVA materials require a geotechnical evaluation prior to use. These materials may not be appropriate due to poor permeability or water caused instability, particularly under wheel loads.



NOTE 1—Drain positioning gate should be located and adjusted to position, and hold the geocomposite drain against the trench wall, to prevent possible "J"ing or "C"ing of the drain during backfilling and compaction.

FIG. 2 Proper Horizontal Alignment

Class	Type	Soil Group Symbol D2487	Description	Percentage Passing Sieve Sizes			Atterberg Limits		Coefficients	
				1 1/2 in (40 mm)	No. 4 (4.75 mm)	No. 200 (0.075 mm)	LL	PL	Uniformity Cu	Curvature Cc
IA	Manufactured Aggregates: open-graded, clean	None	Angular, crushed stone or rock, crushed gravel, broken coral, crushed slag, cinders or shells; large void content, contain little or no fines.	100%	<= 10%	<5%	Non Plastic			
IB	Manufactured. Processed Aggregates; dense-graded, clean.	None	Angular, crushed stone (or other Class 1A materials) and stone/sand mixtures with gradations selected to minimize migration or adjacent soils; contain little or no fines (see X1.8)	100%	<=50%	<5%	Non Plastic			
II	Coarse-Grained Soils, clean.	GW	Well-graded gravels and gravel-sand mixtures; little or no fines.	100%	<50% of "Coarse Fraction"	<5%	Non Plastic		>4	1 to 3
		GP	Poorly-graded gravels and gravel-sand mixtures; little or no fines.						<4	<1 or >3
		SW	Well-graded sands and gravelly sands; little or no fines.		>50% of "Coarse Fraction"				>6	1 to 3
		SP	Poorly-graded sands and gravelly sands; little or no fines.						<6	<1 or >3
	Coarse-Grained Soils, borderline clean to w/fines.	e.g. GW-GC, SP-SM	Sands and gravels which are borderline between clean and with fines.	100%	Varies	5% to 12%	Non Plastic		Same as for GW, GP, SW and SP	
III	Coarse-Grained Soils with Fines	GM	Silty gravels, gravel-sand-silt mixtures.	100%	<50% of "Coarse Fraction"	12% to 50%		<4 or <"A" Line		
		GC	Clayey gravels, gravel-sand-clay mixtures.					<7 and >"A" Line		
		SM	Silty sands, sand-silt mixtures.		>50% of "Coarse Fraction"			>4 or <"A" Line		
		SC	Clayey sands, sand-clay mixtures.					>7 and >"A" Line		
IVA	Fine-Grained Soils (inorganic)	ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands, silts with slight plasticity.	100%	100%	>50%	<50	<4 or <"A" Line		
		CL	Inorganic clays of low to medium plasticity, gravely clays, sandy clays, silty clays, lean clays.					>7 and >"A" Line		
IVB	Fine-Grained Soils (inorganic)	MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts.	100%	100%	>50%	>50	<"A" Line		
		CH	Inorganic clays of high plasticity, fat clays.					>"A" Line		
V	Organic Soils	OL	Organic silts and organic silty clays of low plasticity.	100%	100%	>50%	<50	<4 or <"A" Line		
		OH	Organic clays of medium to high plasticity, organic silts.				>50	<"A" Line		
	Highly Organic	PT	Peat and other high organic soils.							

FIG. 3 Classification of Materials for Potential Use as Embedment and Backfill of Various Components of Subsurface Drainage Systems

7.5 *Moisture Content of Embedment Material*—The moisture content of embedment materials must be within suitable limits to permit placement and compaction to required density levels with reasonable effort.

7.6 *Maximum Aggregate Size*—To enhance placement around geocomposite drains and to prevent damage to these structures, the maximum aggregate size should be 19 mm (0.75 in.).

8. Trench Excavation

8.1 *General*—Procedures for trench excavation that are especially important in the installation of geocomposite drains are given herein.

8.1.1 *Excavation*—Excavate trenches to ensure that sides will be stable and smooth.

Recommendations for Installation and Use of Soils and Aggregates for Foundation, Embedment and Backfill

	Soil Class (see Table 1)				
	Class IA	Class 1B	Class II	Class III	Class IV-A
General Recommendations & Restrictions	Do not use where conditions may cause migration of fines from adjacent soil and loss of drain support. Suitable for use as a drainage blanket and underdrain in rock cuts where adjacent material is suitably graded.	Process materials as required to obtain gradation which will minimize migration of adjacent materials. Suitable for use as drainage blanket and underdrain.	Where hydraulic gradient exists check gradation to minimize migration. "Clean" groups suitable for use as drainage blanket and underdrain.	Do not use where water conditions in trench may cause instability.	Obtain geotechnical evaluation of proposed material. May not be suitable under high earth fills, surface applied wheel loads, and under heavy vibratory compactors and tampers. Do not use where water conditions in trench may cause instability.
Initial Backfill	Suitable as restricted above. Install to a minimum of 6" above drain.	Install and compact to a minimum of 6" above drain.	Suitable as restricted above. Install and compact to a minimum of 6" above drain.	Suitable as restricted above. Install and compact to a minimum of 6" above drain.	Suitable only in dry trench conditions and when optimum placement and compaction control is maintained. Install and compact in 6" maximum layers. Work in around drain by hand to provide uniform support.
Backfill Compaction	Place and work by hand to insure all excavated voids are filled. For high densities use vibratory compactors.	Minimum density 85% Std. Proctor. Use hand tampers or vibratory compactors.	Minimum density 85% Std. Proctor. Use hand tampers or vibratory compactors.	Minimum density 90% Std. Proctor. Use hand tampers or vibratory compactors. Maintain moisture content near optimum to minimize compactive effort.	Minimum density 95% Std. Proctor. Use hand tampers or impact tampers. Maintain moisture content near optimum to minimize compactive effort.
Final Backfill	Compact as required by the engineer.	Compact as required by the engineer.	Compact as required by the engineer.	Compact as required by the engineer.	Suitable as restricted above. Compact as required by the engineer.

FIG. 4 Recommendations for Installation and Use of Soils and Aggregrate for Foundation, Embedment and Backfill

8.2 *Water Control*—Do not lay or embed geocomposite pavement drains in standing or flowing water.

8.3 *Trench Width*—Trench width must be sufficient to provide adequate space for compaction of the backfill using compaction equipment without damaging the geocomposite drainage panel. Specially designed equipment or premium backfill material (such as IA, IB, or II), or both, may enable satisfactory installation in narrower trenches. If it is determined that the use of such equipment and backfill provides an installation consistent with the requirements of this standard, minimum trench widths may be reduced, as approved by the engineer.

9. Installation

9.1 *General*—Recommendations for use of the various types of backfill are classified in Fig. 3 and Fig. 4.

9.2 *Trench Condition*—The following guidance is necessary for satisfactory installation and performance of these products.

9.2.1 *Trench Sidewalls*—If the pavement side trench sidewall is not reasonably straight and smooth, if undercutting or sidewall sloughing occurs, the geocomposite drain material should not be installed against the pavement side trench sidewall. In such cases, the product may be installed in the center of the trench or against the shoulder side wall (as shown in Fig. 1). If installed in the center of the trench, the product must be supported during installation and backfill in such a way as to keep it straight, vertical, and stable. Also, trench width must be increased to a minimum of 150 mm (6 in.) plus the product thickness.

9.2.2 *Trench Depth*—Trench depth is normally determined by application and should be clearly identified on the plans and in the specifications. Trench depth must be sufficient to preclude damage due to later surface (highway or ground) treatments.

9.2.2.1 *Highway Pavement Drainage*—Trench depth shall be sufficient that the drainage product be in contact with the pavement edge to a minimum height of 25 mm (1 in.) above the pavement/base interface and a maximum height of midway up the pavement slab profile to maximize the interception of water within the pavement section (see Fig. 1). A minimum of

25 mm (1 in.) aggregate must separate the top of the panel from the asphalt cap. The panel functions as both a collector and a conduit and needs proper dimensions (height and width), flow capacity, and outlet spacing to maintain the water level in the panel at a depth below the pavement structural layers a majority of the time. This flow should be restricted to that portion of the panel below the base course – subgrade interface as shown in Fig. 1. Based on individual geocomposite drain hydraulic performance, the depth of the panel should be sufficient to carry the design flow below the base course – subgrade interface such that water will not be retained in the structural pavement section.

9.3 *Jointing*—Assembly of joints must not damage the drainage product and should maintain open flow channels, and the planer alignment of the geocomposite drain. Joints must prevent the infiltration of soil particles. When installation is interrupted, secure the product against movement and seal open ends to prevent the entrance of water, mud, or foreign material. When high-speed trenching and installation equipment is used, the joints must be sufficiently strong to withstand installation stresses and strains without separation or damage.

9.4 *Placing and Compacting Backfill*—Place backfill materials by methods that will not disturb or damage the product. Backfill is to be placed in a maximum 150 mm (6 in.) lifts and compacted to a minimum of 90 % standard proctor density (see Test Methods D 698) (T-99). The dragdown forces resulting from placement and compaction of the backfill can cause "C"-ing and "J"-ing distortion as well as geotextile seam failure or geotextile cutting or puncture. "C"-ing and "J"-ing are indicative of the deformed shapes of these materials when installed in a manner that exerts excessive dragdown forces. This distortion can be substantially reduced or eliminated by using compaction equipment and techniques that are compatible with the backfill materials used, trench size, and product location in the trench. Compaction of the first lift should occur with the compaction shoe shielded by the drain positioning gate from geocomposite, as shown in Fig. 2. Excessive compacting may cause panel damage or deformation normal to the plane of the panel and should be avoided.

9.4.1 *Placement of Sand Backfill With Water*—Placement of cohesionless material by watering (flushing or puddling) should only be used in conditions when approved by the engineer. At all times conform to the lift thicknesses and minimum densities given in Fig. 3. In all cases, the system outlets must be installed when watering is used for placement. (Care should be taken to ensure this process does not cause movement of fines to blind the geotextile used with the drainage products).

9.5 *Outlets and Transitions to Pipe*—Outlet tees and transitions to pipe shall connect securely to the geocomposite drainage structure without impeding flow through the product. Panel should not be bent – core reduction occurs when panels are taken out of plane. When the drainage product is placed on a radius to provide a smooth transition to an end outlet, the radius must not restrict flow. Outlets should be installed concurrently with the drainage product, but never more than 48 h after installation of the drainage panel.

9.5.1 *Exposing the Drainage Product For Making Outlet Connections*—When excavating for outlet connections, excavate material from the top of the product before removing material from the side of the product. Exposing of the drainage product for outlet installation should be monitored to determine the condition of the drainage product. Deformed or damaged material should be an indication of the need to modify the installation procedure and backfill to prevent such damage. If there is any torn geotextile, split seams, or damage to any component of the drain that might reduce the designed functionality of the geocomposite, it should be removed and replaced.

9.6 *Drainage Product Caps or Plugs*—Secure end caps or plugs to the drainage product or seal the ends of the drain to prevent piping of fines or other foreign materials into the product.

9.7 *Outlet Pipe*—Outlet pipe shall be of sufficient diameter to remove the collected water from the drainage product at a rate equal to or greater than the flow capacity of the drainage product. Selected pipe should be smooth interior pipe of sufficient stiffness and toughness to withstand anticipated installation stresses and in-service loading conditions without breakage or excessive deflection. Pipe joints shall be soil tight. Outlet pipe should be installed in accordance with Practice D 2321 and should have a minimum slope of 3 %. Outlet ends should be protected from damage and plugging. A rodent screen should be installed in the outlet.

9.8 *Field Monitoring*—Compliance with contract documents with respect to product installation should be monitored by the engineer at a frequency appropriate to project requirements. Excessive post-installation trench settlement and other distress should be monitored carefully by the engineer. Unsatisfactory backfill and/or compaction of the backfill or excessive deformation of the drainage product, or both, will generally cause trench settlement.

10. Keywords

10.1 backfill; "C"-ing; collector; conduit; drain positioning gate; edgedrain; geocomposites; geosynthetic; installation/placement boot; "J"-ing; joints; outlet pipe; outlet tees; trench; underdrain; wheel trencher

APPENDIXES

(Nonmandatory Information)

X1. COMMENTARY

X1.1 Those concerned with the service performance of geocomposite drains should understand factors that can affect this performance. Key considerations in the design and execution of a satisfactory installation of these products, that is the basis for the development of this practice, are given in this appendix.

X1.2 *General*—Subsurface conditions should be adequately investigated prior to construction in accordance with Guide D 420 for use in establishing criteria for correct product placement, backfill materials and construction methods. The type of product selected should be suited to the job conditions.

X1.3 *Load/Compression Performance*—This practice is based upon the use of products that are flexible polymeric structures subject to creep deformation. When carrying load, they depend upon support from the surrounding materials. The design, specification and construction of the drainage system should recognize that backfill conditions and materials must be selected, placed, and compacted so that the product and soil act in concert to carry the applied loads without excessive strains, either vertical, horizontal, or at any load angle.

X1.4 *Compression*—Product compression can result from loads on the drainage product in the process of installing and backfilling, static and live service loads, and soil response. Construction forces, and in-service static and dynamic load-induced compression, must be considered.

X1.5 *Distortion*—These products are intended to provide what is substantially a rectangular, vertical cross-section. Any vertical bending, bowing or buckling, whether construction or load-caused, must be avoided. Such distortion, (as "C"ing or" J"ing) where the core takes a shape similar to the letters "C" or "J" can substantially decrease flow, increase collection of fines, decrease strength to resist compression forces, and raise the effective interior fluid flow line to unacceptable elevations. The use of proper installation techniques can substantially reduce the chance for such deformation to take place.

X1.6 *Backfill Density*—Backfill density requirements should be determined by the engineer based on compression deformation limits for the product used. For those products having a predictable lateral deformation in response to vertical loading and where the lateral expansion is resisted by side soil support, the minimum densities given in Table 2 are based on attaining an average modulus of soil reaction (E') of 6,895 kPa (1 000 PSI), according to Table 6 of Practice D 3839, that relates soil stiffness to soil type and degree of compaction. For particular installations, the project engineer should verify that the density specified meets performance requirements.

X1.7 *Compaction Methods*—Achieving desired densities for specific types of materials depends on the methods used to impart compactive energy. Coarse-grained, clean materials such as crushed stone, gravel, and sand are more readily compacted using vibratory equipment. Fine materials with high plasticity should not be used.

X1.8 *Migration*—When a coarse open-graded material is placed adjacent to a finer material, fines may migrate into the coarser material under the action of hydraulic gradients or pavement pumping of ground water. The application of geotextiles to these products imparts a similar concern of fines passing through the geotextile in sufficient quantities of silt to close the flow path through the product. Conversely, piping of fines towards the soil/fabric interface may result in fabric blinding and reduction (or loss) of system function. Field experience shows that soil migration can result in significant loss of pavement structure support. The gradation and relative size of the embedment and adjacent materials must be compatible in order to minimize migration. In general, avoid placing coarse open-graded materials, such as Class IA in contact with finer materials unless methods are employed to impede migration, such as the use of an appropriate stone filter or filter fabric between the incompatible materials.

X1.8.1 The following filter gradation criteria may minimize migration of fines into the voids of coarser material in the presence of a hydraulic gradient:

X1.8.1.1 $D_{15}/d_{85} < 5$ where D_{15} is the sieve opening size passing 15 % by weight of the coarser material and d_{85} is the sieve opening size passing 85 % by weight of the finer material.

X1.8.1.2 $D_{50}/d_{50} < 25$ where D_{50} is the sieve opening size passing 50 % by weight of the coarser material and d_{50} is the sieve opening size passing 50 % by weight of the finer material. This criterion need not apply if the coarser material is well graded. (See Classification D 2487.)

X1.8.1.3 If the finer material is a medium to highly plastic clay without sand or silt partings (CL or CH), then the following criterion may be used in lieu of X1.8.1.1:

$$D_{15} < 0.5\ mm\ \ (0.02\ in.)$$

where:

D_{15} = the sieve opening size passing 15 % by weight of the coarser material.

X2. RECOMMENDATIONS FOR INCORPORATION IN CONTRACT DOCUMENTS

X2.1 This practice may be incorporated, by referral, into contract documents for a specific project to cover requirements for installation of geocomposite, flat-pipe, or panel type underdrain systems. Application to a particular project should be made by means of a list of supplemental requirements. Suggested modifications to specific sections are listed below:

X2.2 *Sections 5.1, 5.2, and Table 2*—Further restrictions on the use of classes of backfill materials.

X2.3 *Section 5*—Specific gradations of backfill material for resistance to migration.

X2.4 *Section 5.5*—Maximum Particle Size, if different from the 19 mm (0.75 in.) given.

X2.5 *Section 6.3*—Restrictions on trench width.

X2.6 *Section 7.2.1*—Location of the product in the trench

X2.7 *Section 7.2.2*—Trench depth and corresponding product height requirements.

X2.8 *Section 7.4*—Specific restrictions on methods of compaction.

X2.9 *Section 7.5*—Details for outlet connections.