SECTION 33 46 00 – subdrainage

1. General
   1. Summary
      1. Section Includes:
         1. Perforated-wall pipe and fittings.
         2. Drainage conduits.
         3. Drainage panels.
         4. Geotextile filter fabrics.
   2. ACTION SUBMITTALS
      1. Product Data:
         1. Drainage conduits, including rated capacities.
         2. Drainage panels, including rated capacities.
         3. Geotextile filter fabrics.
2. Products
   1. PERFORATED-WALL PIPES AND FITTINGS

Pipe materials in this article have perforated walls and typically are joined with loose joints.

Retain one or both paragraphs below. If both are required, show installation location of each on Drawings.

* + 1. Perforated PE Pipe and Fittings:

Pipe and fittings in first subparagraph below are available in NPS 3 to NPS 6 (DN 80 to DN 150). Joints are coupling type.

* + - 1. NPS 6 (DN 150) and Smaller: ASTM F405 or AASHTO M 252, Type CP; corrugated, for coupled joints.

Pipe and fittings in first subparagraph below are available in NPS 8 to NPS 24 (DN 200 to DN 600). Joints are coupling type.

* + - 1. NPS 8 (DN 200) and Larger: ASTM F667; AASHTO M 252, Type CP; or AASHTO M 294, Type CP; corrugated; for coupled joints.
      2. Couplings: Manufacturer's standard, band type.

Pipe and fittings in paragraph below are available in NPS 4 (DN 100) only. Joints are bell-and-spigot, loose type.

* + 1. Perforated PVC Sewer Pipe and Fittings: ASTM D2729, bell-and-spigot ends, for loose joints.
  1. DRAINAGE CONDUITS

ASTM D4716 computes in-plane flow rate by gpm/ft. (cu. m/s per m) of unit width. Manufacturers typically use gpm (L/min.) for an indicated size, and this unit of measure is used for drainage conduits in this Section for ease of comparison. Verify flow of retained drainage conduits.

* + 1. Molded-Sheet Drainage Conduits: Prefabricated geocomposite with cuspated, molded-plastic drainage core wrapped in geotextile filter fabric.

See Editing Instruction No. 1 in the Evaluations for cautions about naming manufacturers. Retain one of first two subparagraphs and list of manufacturers below. See Section 01 61 00 – Common Product Requirements.

Retain option in first subparagraph below if manufacturer's name and model number are indicated in schedules or plans on Drawings; delete option and insert manufacturer's name and model number if not included on Drawings.

Retain "Manufacturers" Subparagraph below and list of manufacturers to require products from manufacturers listed or a comparable product from other manufacturers.

* + - 1. Manufacturers: Subject to compliance with requirements, [provide products by the following] [provide products by one of the following] [available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
         1. Airfield Systems, LLC.
         2. American Wick Drain.
         3. JDR Enterprises, Inc.
         4. MAPEI Corporation.
         5. TenCate Geosynthetics.
         6. <Insert manufacturer's name>.

Retain one of two "Nominal Size" subparagraphs below.

* + - 1. Nominal Size: 12 inches (305 mm) high by approximately 1 inch (25 mm) thick.
         1. Minimum In-Plane Flow: [30 gpm (114 L/min.)] <Insert value> at hydraulic gradient of [1.0] <Insert value> when tested according to ASTM D4716.
      2. Nominal Size: 18 inches (457 mm) high by approximately 1 inch (25 mm) thick.
         1. Minimum In-Plane Flow: [45 gpm (170 L/min.)] <Insert value> at hydraulic gradient of [1.0] <Insert value> when tested according to ASTM D4716.

Retain two subparagraphs below with either "Nominal Size" Subparagraph retained above.

* + - 1. Filter Fabric: PP geotextile.
      2. Fittings: HDPE with combination NPS 4 and NPS 6 (DN 100 and DN 150) outlet connection.
    1. Multipipe Drainage Conduits: Prefabricated geocomposite with interconnected, corrugated, perforated-pipe core molded from HDPE complying with ASTM D1248 and wrapped in geotextile filter fabric.

See Editing Instruction No. 1 in the Evaluations for cautions about naming manufacturers. Retain one of first two subparagraphs and list of manufacturers below. See Section 01 61 00 – Common Product Requirements.

Retain option in first subparagraph below if manufacturer's name and model number are indicated in schedules or plans on Drawings; delete option and insert manufacturer's name and model number if not included on Drawings.

Retain "Manufacturers" Subparagraph below and list of manufacturers to require products from manufacturers listed or a comparable product from other manufacturers.

* + - 1. Manufacturers: Subject to compliance with requirements, [provide products by the following] [provide products by one of the following] [available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
         1. Varicore Technologies, Inc.
         2. <Insert manufacturer's name>.

Retain one of three "Nominal Size" subparagraphs below.

* + - 1. Nominal Size: 6 inches (152 mm) high by approximately 1-1/4 inches (31 mm) thick.
         1. Minimum In-Plane Flow: [15 gpm (57 L/min.)] <Insert value> at hydraulic gradient of [1.0] <Insert value> when tested according to ASTM D4716.
      2. Nominal Size: 12 inches (305 mm) high by approximately 1-1/4 inches (31 mm) thick.
         1. Minimum In-Plane Flow: [30 gpm (114 L/min.)] <Insert value> at hydraulic gradient of [1.0] <Insert value> when tested according to ASTM D4716.
      3. Nominal Size: 18 inches (457 mm) high by approximately 1-1/4 inches (31 mm) thick.
         1. Minimum In-Plane Flow: [45 gpm (170 L/min.)] <Insert value> at hydraulic gradient of [1.0] <Insert value> when tested according to ASTM D4716.

Retain three subparagraphs below with one of three "Nominal Size" subparagraphs retained above.

* + - 1. Filter Fabric: Nonwoven, needle-punched geotextile.
      2. Fittings: HDPE with combination NPS 4 and NPS 6 (DN 100 and DN 150) outlet connection.
      3. Couplings: HDPE.
    1. Single-Pipe Drainage Conduits: Prefabricated geocomposite with perforated corrugated core molded from HDPE complying with ASTM D3350 and wrapped in geotextile filter fabric.

See Editing Instruction No. 1 in the Evaluations for cautions about naming manufacturers. Retain one of first two subparagraphs and list of manufacturers below. See Section 01 61 00 – Common Product Requirements.

Retain option in first subparagraph below if manufacturer's name and model number are indicated in schedules or plans on Drawings; delete option and insert manufacturer's name and model number if not included on Drawings.

Retain "Manufacturers" Subparagraph below and list of manufacturers to require products from manufacturers listed or a comparable product from other manufacturers.

* + - 1. Manufacturers: Subject to compliance with requirements, [provide products by the following] [provide products by one of the following] [available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
         1. Advanced Drainage Systems, Inc.
         2. <Insert manufacturer's name>.

Retain one of two "Nominal Size" subparagraphs below.

* + - 1. Nominal Size: 12 inches (305 mm) high by approximately 1 inch (25 mm) thick.
         1. Minimum In-Plane Flow: [30 gpm (114 L/min.)] <Insert value> at hydraulic gradient of [1.0] <Insert value> when tested according to ASTM D4716.
      2. Nominal Size: 18 inches (457 mm) high by approximately 1 inch (25 mm) thick.
         1. Minimum In-Plane Flow: [45 gpm (170 L/min.)] <Insert value> at hydraulic gradient of [1.0] <Insert value> when tested according to ASTM D4716.

Retain three subparagraphs below with either "Nominal Size" Subparagraph retained above.

* + - 1. Filter Fabric: PP geotextile.
      2. Fittings: HDPE with combination NPS 4 and NPS 6 (DN 100 and DN 150) outlet connection.
      3. Couplings: Corrugated HDPE band.
    1. Mesh Fabric Drainage Conduits: Prefabricated geocomposite with plastic-filament drainage core wrapped in geotextile filter fabric. Include fittings for bends and connection to drainage piping.

See Editing Instruction No. 1 in the Evaluations for cautions about naming manufacturers. Retain one of first two subparagraphs and list of manufacturers below. See Section 01 61 00 – Common Product Requirements.

Retain option in first subparagraph below if manufacturer's name and model number are indicated in schedules or plans on Drawings; delete option and insert manufacturer's name and model number if not included on Drawings.

Retain "Manufacturers" Subparagraph below and list of manufacturers to require products from manufacturers listed or a comparable product from other manufacturers.

* + - 1. Manufacturers: Subject to compliance with requirements, [provide products by the following] [provide products by one of the following] [available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
         1. Bonar Inc.; a Low & Bonar company.
         2. <Insert manufacturer's name>.
      2. Nominal Size: 6 inches (150-mm) high by approximately 0.9 inch (23 mm) thick.
         1. Minimum In-Plane Flow: [2.4 gpm (9.1 L/min.)] <Insert value> at hydraulic gradient of [1.0] <Insert value> when tested according to ASTM D4716.
      3. Filter Fabric: Nonwoven geotextile made of PP or polyester fibers or combination of both. Flow rates range from 120 to 200 gpm/sq. ft. (81 to 136 L/s per sq. m) when tested according to ASTM D4491.
    1. Ring Fabric Drainage Conduits: Drainage conduit with HDPE rings-in-grid pattern drainage core, for field-applied geotextile filter fabric. Include fittings for bends and connection to drainage piping.

See Editing Instruction No. 1 in the Evaluations for cautions about naming manufacturers. Retain one of first two subparagraphs and list of manufacturers below. See Section 016000 "Product Requirements."

Retain option in first subparagraph below if manufacturer's name and model number are indicated in schedules or plans on Drawings; delete option and insert manufacturer's name and model number if not included on Drawings.

Retain "Manufacturers" Subparagraph below and list of manufacturers to require products from manufacturers listed or a comparable product from other manufacturers.

* + - 1. Manufacturers: Subject to compliance with requirements, [provide products by the following] [provide products by one of the following] [available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
         1. Invisible Structures, Inc.
         2. <Insert manufacturer's name>.

Retain one of two "Nominal Size" subparagraphs below.

* + - 1. Nominal Size: 18 inches (0.5 m) high by 1 inch (25 mm) thick.
         1. Minimum In-Plane Flow: [82 gpm (310 L/min.)] <Insert value> at hydraulic gradient of [1.0] <Insert value> when tested according to ASTM D4716.
      2. Nominal Size: 36 inches (1 m) high by 1 inch (25 mm) thick.
         1. Minimum In-Plane Flow: [164 gpm (621 L/min.)] <Insert value> at hydraulic gradient of [1.0] <Insert value> when tested according to ASTM D4716.

Retain subparagraph below with either "Nominal Size" Subparagraph retained above.

* + - 1. Filter Fabric: Comply with requirements for flat geotextile filter fabric specified in Part 2 "Geotextile Filter Fabrics" Article.
  1. DRAINAGE PANELS

Retain this article if drainage panels are required and are not part of a waterproofing system or delete if drainage panels are specified in Section 07 13 26 – Self-Adhering Sheet Waterproofing, Section 07 13 53 – Elastomeric Sheet Waterproofing, Section 07 13 54 – Thermoplastic Sheet Waterproofing, Section 07 14 13 – Hot Fluid-Applied Rubberized Asphalt Waterproofing, Section 07 14 16 – Cold Fluid-Applied Waterproofing, or Section 07 17 00 – Bentonite Waterproofing.

ASTM D4716 computes in-plane flow rate by gpm/ft. (cu. m/s per m) of unit width. Manufacturers typically use gpm/ft. (L/min. per m) of unit width, and this unit of measure is used for drainage panels in this Section for ease of comparison. Verify flow rate of retained drainage panels.

* + 1. Molded-Sheet Drainage Panels: Prefabricated geocomposite, [36 to 60 inches (915 to 1525 mm)] <Insert dimension> wide with drainage core faced with geotextile filter fabric.

See Editing Instruction No. 1 in the Evaluations for cautions about naming manufacturers. Retain one of first two subparagraphs and list of manufacturers below. See Section 01 61 00 – Common Product Requirements.

Retain option in first subparagraph below if manufacturer's name and model number are indicated in schedules or plans on Drawings; delete option and insert manufacturer's name and model number if not included on Drawings.

Retain "Manufacturers" Subparagraph below and list of manufacturers to require products from manufacturers listed or a comparable product from other manufacturers.

* + - 1. Manufacturers: Subject to compliance with requirements, [provide products by the following] [provide products by one of the following] [available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
         1. American Wick Drain.
         2. Dorken Systems Inc.
         3. Eljen Corporation.
         4. JDR Enterprises, Inc.
         5. MAPEI Corporation.
         6. Mar-flex Waterproofing & Building Products.
         7. Midwest Diversified Technologies Incorporated.
         8. Sika Greenstreak.
         9. TenCate Geosynthetics.
         10. Trace-LINQ Inc.
         11. <Insert manufacturer's name>.
      2. Drainage Core: Three-dimensional, nonbiodegradable, molded PP.
         1. Minimum Compressive Strength: [10,000 lbf/sq. ft. (479 kPa)] [15,000 lbf/sq. ft. (718 kPa)] [18,000 lbf/sq. ft. (862 kPa)] [21,000 lbf/sq. ft. (1005 kPa)] <Insert value> when tested according to ASTM D1621.

Flow rate varies with hydraulic gradient, thickness, and capacity of drainage core. A hydraulic gradient of 1.0 is commonly quoted for vertical applications with maximum gravity flow. Horizontal applications will have reduced flow rates, and manufacturers commonly report tests at hydraulic gradients of 0.05 or 0.1. Flow rate is also influenced by compressive loading of drainage panel. Manufacturers report various values such as 3600 lbf/sq. ft. or 25 psig (172 kPa).

* + - * 1. Minimum In-Plane Flow Rate: [2.8 gpm/ft. (35 L/min. per m)] [7 gpm/ft. (87 L/min. per m)] [15 gpm/ft. (186 L/min. per m)] <Insert value> of unit width at hydraulic gradient of [1.0] <Insert value> and compressive stress of [25 psig (172 kPa)] <Insert value> when tested according to ASTM D4716.

Retain nonwoven geotextile and properties in first subparagraph below for walls and other applications if applicable.

* + - 1. Filter Fabric: Nonwoven needle-punched geotextile, manufactured for subsurface drainage, made from polyolefins or polyesters; with elongation greater than 50 percent; complying with the following properties determined according to AASHTO M 288:

Survivability rates a geotextile's ability to withstand installation stresses and is divided into three classes by AASHTO M 288. Survivability measures grab, seam, tear, puncture, and burst strength. Class 2 is a default class recommended by AASHTO M 288 for subsurface drainage. Retain Class 1 in first subparagraph below if higher strength is required; retain Class 3 if lower strength is sufficient.

* + - * 1. Survivability: [Class 1] [Class 2] [Class 3].

AASHTO M 288 bases retention of apparent opening size on percentages of backfill soils passing a No. 200 (0.075-mm) sieve. First option in first subparagraph below coordinates to less than 15 percent; second, 15 to 50 percent; and third, greater than 50 percent for Class 2 geotextiles.

* + - * 1. Apparent Opening Size: [No. 40 (0.425-mm)] [No. 60 (0.25-mm)] [No. 70 (0.212-mm)] sieve, maximum.

AASHTO M 288 bases retention of permittivity on percentages of backfill soils passing a No. 200 (0.075-mm) sieve. First option in first subparagraph below coordinates to less than 15 percent; second, 15 to 50 percent; and third, greater than 50 percent for Class 2 geotextiles.

* + - * 1. Permittivity: [0.5] [0.2] [0.1] per second, minimum.

Woven geotextile type in first subparagraph below is sometimes used for deck or plaza applications. Verify retentions with geotextile and waterproofing manufacturers if required. Woven geotextiles have a range of permeability and opening sizes and may be classified by AASHTO M 288 into subsurface drainage as well as separation applications.

* + - 1. Filter Fabric: Woven geotextile fabric, manufactured for subsurface drainage, made from polyolefins or polyesters; with elongation less than 50 percent; complying with the following properties determined according to AASHTO M 288:

Survivability rates a geotextile's ability to withstand installation stresses and is divided into three classes by AASHTO M 288. Survivability measures grab, seam, tear, puncture, and burst strength. Class 2 is default class recommended by AASHTO M 288 for subsurface drainage and separation applications. Retain Class 1 in first subparagraph below if higher strength is required; retain Class 3 if lower strength is sufficient.

* + - * 1. Survivability: [Class 1] [Class 2] [Class 3].

AASHTO M 288 bases retention of apparent opening size on percentages of backfill soils passing a No. 200 (0.075-mm) sieve. First option in first subparagraph below coordinates with less than 15 percent; second, 15 to 50 percent; and third, greater than 50 percent for Class 2 geotextiles for subsurface applications. Fourth option coordinates with AASHTO M 288 default value for Class 2 separation rather than subsurface applications.

* + - * 1. Apparent Opening Size: [No. 40 (0.425-mm)] [No. 60 (0.25-mm)] [No. 70 (0.212-mm)] [No. 30 (0.6-mm)] sieve, maximum.

AASHTO M 288 bases retention of permittivity on percentages of backfill soils passing a No. 200 (0.075-mm) sieve. First option in first subparagraph below coordinates with less than 15 percent; second, 15 to 50 percent; and third, greater than 50 percent for Class 2 geotextiles for subsurface applications. Fourth option coordinates with AASHTO M 288 default value for Class 2 separation rather than subsurface applications.

* + - * 1. Permittivity: [0.5] [0.2] [0.1] [0.02] per second, minimum.

Retain subparagraph below if drainage panel also acts as protection course on vertical or wall applications. Soft waterproofing membranes can be damaged by drainage core during backfilling and under permanent soil pressure.

* + - 1. Film Backing: Polymeric film bonded to drainage core surface.
    1. Mesh Fabric Drainage Panels: Prefabricated geocomposite with drainage core faced with geotextile filter fabric.

See Editing Instruction No. 1 in the Evaluations for cautions about naming manufacturers. Retain one of first two subparagraphs and list of manufacturers below. See Section 01 61 00 – Common Product Requirements.

Retain option in first subparagraph below if manufacturer's name and model number are indicated in schedules or plans on Drawings; delete option and insert manufacturer's name and model number if not included on Drawings.

Retain "Manufacturers" Subparagraph below and list of manufacturers to require products from manufacturers listed or a comparable product from other manufacturers.

* + - 1. Manufacturers: Subject to compliance with requirements, [provide products by the following] [provide products by one of the following] [available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
         1. Bonar Inc.; a Low & Bonar company.
         2. <Insert manufacturer's name>.
      2. Drainage Core: Open-construction, resilient, plastic-filament mesh, approximately 0.4 inches (10.2 mm) thick.
         1. Minimum In-Plane Flow Rate: [2.4 gpm/ft. (30 L/min. per m)] <Insert value> of unit width at hydraulic gradient of [1.0] <Insert value> and normal pressure of 25 psig (172 kPa) when tested according to ASTM D4716.
      3. Filter Fabric: Nonwoven geotextile of PP or polyester fibers or combination of both. Flow rates range from 120 to 200 gpm/sq. ft. (81 to 136 L/s per sq. m) when tested according to ASTM D4491.
    1. Net Fabric Drainage Panels: Prefabricated geocomposite with drainage core faced with geotextile filter fabric.

See Editing Instruction No. 1 in the Evaluations for cautions about naming manufacturers. Retain one of first two subparagraphs and list of manufacturers below. See Section 01 61 00 – Common Product Requirements.

Retain option in first subparagraph below if manufacturer's name and model number are indicated in schedules or plans on Drawings; delete option and insert manufacturer's name and model number if not included on Drawings.

Retain "Manufacturers" Subparagraph below and list of manufacturers to require products from manufacturers listed or a comparable product from other manufacturers.

* + - 1. Manufacturers: Subject to compliance with requirements, [provide products by the following] [provide products by one of the following] [available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
         1. GSE Lining Technology, Inc.
         2. JDR Enterprises, Inc.
         3. Strata Systems, Inc.
         4. <Insert manufacturer's name>.
      2. Drainage Core: Three-dimensional, PE nonwoven-strand geonet, approximately 0.25 inches (6 mm) thick.
         1. Minimum In-Plane Flow Rate: [2.4 gpm/ft. (30 L/min. per m)] [5 gpm/ft. (62 L/min. per m)] <Insert value> of unit width at hydraulic gradient of [1.0] <Insert value> and normal pressure of 25 psig (172 kPa) when tested according to ASTM D4716.
      3. Filter Fabric: Nonwoven geotextile of PP or polyester fibers or combination of both. Flow rates range from 120 to 200 gpm/sq. ft. (81 to 136 L/s per sq. m) when tested according to ASTM D4491.

Drainage panels in paragraph below require field application of geotextile filter fabric.

* + 1. Ring Fabric Drainage Panels: Drainage-core panel for field application of geotextile filter fabric.

See Editing Instruction No. 1 in the Evaluations for cautions about naming manufacturers. Retain one of first two subparagraphs and list of manufacturers below. See Section 01 61 00 – Common Product Requirements.

Retain option in first subparagraph below if manufacturer's name and model number are indicated in schedules or plans on Drawings; delete option and insert manufacturer's name and model number if not included on Drawings.

Retain "Manufacturers" Subparagraph below and list of manufacturers to require products from manufacturers listed or a comparable product from other manufacturers.

* + - 1. Manufacturers: Subject to compliance with requirements, [provide products by the following] [provide products by one of the following] [available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
         1. Invisible Structures, Inc.
         2. <Insert manufacturer's name>.
      2. Drainage Core: Three-dimensional, HDPE rings-in-grid pattern, approximately 1 inch (25 mm) thick.
         1. Minimum In-Plane Flow Rate: [40 gpm/ft. (500 L/min. per m)] <Insert value> of unit width at hydraulic gradient of [1.0] <Insert value> and normal pressure of 25 psig (172 kPa) when tested according to ASTM D4716.
  1. SOIL MATERIALS
     1. Soil materials are specified in Section 312000 "Earth Moving."
  2. WATERPROOFING FELTS
     1. Material: Comply with [ASTM D226, Type I, asphalt] [or] [ASTM D227, coal-tar]-saturated organic felt.
  3. GEOTEXTILE FILTER FABRICS
     1. Description: Fabric of PP or polyester fibers or combination of both, with flow rate range from 110 to 330 gpm/sq. ft. (4480 to 13 440 L/min. per sq. m) when tested according to ASTM D4491.
     2. Structure Type: Nonwoven, needle-punched continuous filament.

Class 2 in first subparagraph below is the default class recommended by AASHTO.

* + - 1. Survivability: AASHTO [M 288 Class 2] <Insert class>.
      2. Styles: Flat and sock.

1. Execution
   1. examination
      1. Examine surfaces and areas for suitable conditions where subdrainage systems are to be installed.

Retain first paragraph below if subdrainage system is required for landscaped areas.

* + 1. If subdrainage is required for landscaping, locate and mark existing utilities, underground structures, and aboveground obstructions before beginning installation and avoid disruption and damage of services.

Retain first paragraph below if drainage panels are specified in a waterproofing Section.

* + 1. Verify that drainage panels installed as part of foundation wall waterproofing is properly positioned to drain into subdrainage system.
    2. Proceed with installation only after unsatisfactory conditions have been corrected.
  1. EARTHWORK
     1. Excavating, trenching, and backfilling are specified in Section 312000 "Earth Moving."
  2. FOUNDATION DRAINAGE INSTALLATION
     1. Place impervious fill material on subgrade adjacent to bottom of footing after concrete footing forms have been removed. Place and compact impervious fill to dimensions indicated, but not less than 6 inches (150 mm) deep and 12 inches (300 mm) wide.
     2. Lay flat-style geotextile filter fabric in trench and overlap trench sides.
     3. Place supporting layer of drainage course over compacted subgrade and geotextile filter fabric, to compacted depth of not less than 4 inches (100 mm).
     4. Encase pipe with sock-style geotextile filter fabric before installing pipe. Connect sock sections with [**adhesive**] [**or**] [**tape**].
     5. Install drainage piping as indicated in Part 3 "Piping Installation" Article for foundation subdrainage.
     6. Add drainage course to width of at least 6 inches (150 mm) on side away from wall and to top of pipe to perform tests.
     7. After satisfactory testing, cover drainage piping to width of at least 6 inches (150 mm) on side away from footing and above top of pipe to within 12 inches (300 mm) of finish grade.
     8. Install drainage course and wrap top of drainage course with flat-style geotextile filter fabric.
     9. Place layer of [**flat-style geotextile filter fabric**] [**waterproofing felt**] over top of drainage course, overlapping edges at least 4 inches (100 mm).
     10. Install drainage panels on foundation walls as follows:
         1. Coordinate placement with other drainage materials.
         2. Lay perforated drainage pipe at base of footing. Install as indicated in Part 3 "Piping Installation" Article.
         3. Separate 4 inches (100 mm) of fabric at beginning of roll and cut away 4 inches (100 mm) of core. Wrap fabric around end of remaining core.
         4. Attach panels to wall beginning at subdrainage pipe. Place and secure molded-sheet drainage panels, with geotextile facing away from wall.
     11. Place backfill material over compacted drainage course. Place material in loose-depth layers not exceeding 6 inches (150 mm). Thoroughly compact each layer. Final backfill to finish elevations and slope away from building.
  3. UNDERSLAB DRAINAGE INSTALLATION
     1. Excavate for underslab drainage system after subgrade material has been compacted but before drainage course has been placed. Include horizontal distance of at least 6 inches (150 mm) between drainage pipe and trench walls. Grade bottom of trench excavations to required slope, and compact to firm, solid bed for drainage system.
     2. Lay flat-style geotextile filter fabric in trench and overlap trench sides.
     3. Place supporting layer of drainage course over compacted subgrade and geotextile filter fabric, to compacted depth of not less than 4 inches (100 mm).
     4. Encase pipe with sock-style geotextile filter fabric before installing pipe. Connect sock sections with [**adhesive**] [**or**] [**tape**].
     5. Install drainage piping as indicated in Part 3 "Piping Installation" Article for underslab subdrainage.
     6. Add drainage course to width of at least 6 inches (150 mm) on side away from wall and to top of pipe to perform tests.
     7. After satisfactory testing, cover drainage piping with drainage course to elevation of bottom of slab, and compact and wrap top of drainage course with flat-style geotextile filter fabric.
     8. Install horizontal drainage panels as follows:
        1. Coordinate placement with other drainage materials.
        2. Lay perforated drainage pipe at inside edge of footing.
        3. Place drainage panel over drainage pipe with core side up. Peel back fabric and wrap fabric around pipe. Locate top of core at bottom elevation of floor slab.
        4. Butt additional panels against other installed panels. If panels have plastic flanges, overlap installed panel with flange.
  4. RETAINING-WALL DRAINAGE INSTALLATION

Retain one of first two paragraphs below.

* + 1. Lay flat-style geotextile filter fabric in trench and overlap trench sides.
    2. Place supporting layer of drainage course over compacted subgrade to compacted depth of not less than 4 inches (100 mm).
    3. Encase pipe with sock-style geotextile filter fabric before installing pipe. Connect sock sections with [**adhesive**] [**or**] [**tape**].
    4. Install drainage piping as indicated in Part 3 "Piping Installation" Article for retaining-wall subdrainage.
    5. Add drainage course to width of at least 6 inches (150 mm) on side away from wall and to top of pipe to perform tests.
    6. After satisfactory testing, cover drainage piping to width of at least 6 inches (150 mm) on side away from footing and above top of pipe to within 12 inches (300 mm) of finish grade.
    7. Place drainage course in layers not exceeding 3 inches (75 mm) in loose depth; compact each layer placed and wrap top of drainage course with flat-style geotextile filter fabric.
    8. Place layer of [**flat-style geotextile filter fabric**] [**waterproofing felt**] over top of drainage course, overlapping edges at least 4 inches (100 mm).
    9. Install drainage panels on wall as follows:
       1. Coordinate placement with other drainage materials.

Retain one of first two subparagraphs below.

* + - 1. Lay perforated drainage pipe at base of footing as described elsewhere in this Specification. Do not install aggregate.
      2. If weep holes are used instead of drainage pipe, cut 1/2-inch- (13-mm-) diameter holes on core side at weep-hole locations. Do not cut fabric.
      3. Mark horizontal calk line on wall at a point 6 inches (150 mm) less than panel width above footing bottom. Before marking wall, subtract footing width.
      4. Separate 4 inches (100 mm) of fabric at beginning of roll and cut away 4 inches (100 mm) of core. Wrap fabric around end of remaining core.

Retain first subparagraph below if pipe is used.

* + - 1. Attach panel to wall at horizontal mark and at beginning of wall corner. Place core side of panel against wall. Use concrete nails with washers through product. Place nails from 2 to 6 inches (50 to 150 mm) below top of panel, approximately 48 inches (1200 mm) apart.[**Construction adhesives, metal stick pins, or double-sided tape may be used instead of nails.**] Do not penetrate waterproofing. Before using adhesives, discuss with waterproofing manufacturer.
      2. If another panel is required on same row, cut away 4 inches (100 mm) of installed panel core and wrap fabric over new panel.
      3. If additional rows of panel are required, overlap lower panel with 4 inches (100 mm) of fabric.
      4. Cut panel as necessary to keep top 12 inches (300 mm) below finish grade.
      5. For inside corners, bend panel. For outside corners, cut core to provide 3 inches (75 mm) for overlap.
    1. Fill to Grade: Place satisfactory soil fill material over compacted drainage course. Place material in loose-depth layers not exceeding 6 inches (150 mm). Thoroughly compact each layer. Fill to finish grade.
  1. LANDSCAPING DRAINAGE INSTALLATION
     1. Provide trench width to allow installation of drainage conduit. Grade bottom of trench excavations to required slope, and compact to firm, solid bed for drainage system.
     2. Lay flat-style geotextile filter fabric in trench and overlap trench sides.
     3. Place supporting layer of drainage course over compacted subgrade and geotextile filter fabric, to compacted depth of not less than 4 inches (100 mm).
     4. Install drainage conduits as indicated in Part 3 "Piping Installation" Article for landscaping subdrainage with horizontal distance of at least 6 inches (150 mm) between conduit and trench walls. Wrap drainage conduits without integral geotextile filter fabric with flat-style geotextile filter fabric before installation. Connect fabric sections with [**adhesive**] [**or**] [**tape**].
     5. Add drainage course to top of drainage conduits.
     6. After satisfactory testing, cover drainage conduit to within 12 inches (300 mm) of finish grade.
     7. Install drainage course and wrap top of drainage course with flat-style geotextile filter fabric.
     8. Place layer of [**flat-style geotextile filter fabric**] [**waterproofing felt**] over top of drainage course, overlapping edges at least 4 inches (100 mm).
     9. Fill to Grade: Place satisfactory soil fill material over drainage course. Place material in loose-depth layers not exceeding 6 inches (150 mm). Thoroughly compact each layer. Fill to finish grade.
  2. PIPING INSTALLATION

Show relationships of piping and other materials on Drawings.

* + 1. Install piping beginning at low points of system, true to grades and alignment indicated, with unbroken continuity of invert. Bed piping with full bearing in filtering material. Install gaskets, seals, sleeves, and couplings according to manufacturer's written instructions and other requirements indicated.

Of first five subparagraphs below, retain only those applicable to Project. Revise first subparagraph below as required for different minimum cover.

* + - 1. Foundation Subdrainage: Install piping level and with a minimum cover of [36 inches (915 mm)] <**Insert dimension**> unless otherwise indicated.
      2. Underslab Subdrainage: Install piping level.
      3. Plaza Deck Subdrainage: Install piping level.
      4. Retaining-Wall Subdrainage: When water discharges at end of wall into stormwater piping system, install piping level and with a minimum cover of [36 inches (915 mm)] <**Insert dimension**> unless otherwise indicated.

Revise first subparagraph below as required for different minimum slope and cover.

* + - 1. Landscaping Subdrainage: Install piping pitched down in direction of flow, at a minimum slope of [**0.5**] <**Insert value**> percent and with a minimum cover of [36 inches (915 mm)] <**Insert dimension**> unless otherwise indicated.
      2. Lay perforated pipe with perforations down.

Revise subparagraph below to suit Project or delete.

* + - 1. Excavate recesses in trench bottom for bell ends of pipe. Lay pipe with bells facing upslope and with spigot end entered fully into adjacent bell.
    1. Use increasers, reducers, and couplings made for different sizes or materials of pipes and fittings being connected. Reduction of pipe size in direction of flow is prohibited.
    2. Install thermoplastic piping according to ASTM D2321.
  1. PIPE JOINT CONSTRUCTION
     1. Join perforated PE pipe and fittings with couplings according to ASTM D3212 with loose banded, coupled, or push-on joints.
     2. Join perforated PVC sewer pipe and fittings according to ASTM D3212 with loose bell-and-spigot, push-on joints.
     3. Special Pipe Couplings: Join piping made of different materials and dimensions with special couplings made for this application. Use couplings that are compatible with and fit materials and dimensions of both pipes.
  2. BACKWATER VALVE INSTALLATION
     1. Comply with requirements for backwater valves specified in Section 334100 "Storm Utility Drainage Piping."
     2. Install horizontal backwater valves in header piping downstream from perforated subdrainage piping.

Backwater valves must be accessible for maintenance. Detail backwater valves and manholes or pits if backwater valve's check valve cannot be reached from the surface.

* + 1. Install horizontal backwater valves in piping[**in manholes or pits**] where indicated.
  1. CLEANOUT INSTALLATION
     1. Comply with requirements for cleanouts specified in Section 334100 "Storm Utility Drainage Piping."
     2. Cleanouts for [**Foundation**] [**Retaining-Wall**] [**and**] [**Landscaping**] Subdrainage:
        1. Install cleanouts from piping to grade. Locate cleanouts at beginning of piping run and at changes in direction. Install fittings so cleanouts open in direction of flow in piping.
        2. In vehicular-traffic areas, use NPS 4 (DN 100) cast-iron soil pipe and fittings for piping branch fittings and riser extensions to cleanout. Set cleanout frames and covers in a cast-in-place concrete anchor, [18 by 18 by 12 inches (450 by 450 by 300 mm)] <**Insert dimensions**> deep. Set top of cleanout flush with grade.
        3. In nonvehicular-traffic areas, use NPS 4 (DN 100) [**cast-iron**] [**PVC**] pipe and fittings for piping branch fittings and riser extensions to cleanout. Set cleanout frames and covers in a cast-in-place concrete anchor, [12 by 12 by 4 inches (300 by 300 by 100 mm)] <**Insert dimensions**> deep. Set top of cleanout [1 inch (25 mm)] [2 inches (50 mm)] <**Insert dimension**> above grade.
        4. Comply with requirements for concrete specified in Section 033000 "Cast-in-Place Concrete."
     3. Cleanouts for Underslab Subdrainage:
        1. Install cleanouts and riser extensions from piping to top of slab. Locate cleanouts at beginning of piping run and at changes in direction. Install fittings so cleanouts open in direction of flow in piping.
        2. Use NPS 4 (DN 100) cast-iron soil pipe and fittings for piping branch fittings and riser extensions to cleanout flush with top of slab.
  2. CONNECTIONS

Coordinate piping installations and specialty arrangements with schematics on Drawings and with requirements specified in piping systems. If Drawings are explicit enough, these requirements may be reduced or omitted.

* + 1. Comply with requirements for piping specified in Section 334100 "Storm Utility Drainage Piping." Drawings indicate general arrangement of piping, fittings, and specialties.

Retain option in first paragraph below if connection will be to building's storm drainage system.

* + 1. Connect low elevations of subdrainage system to[**building's**] solid-wall-piping storm drainage system.

Retain paragraph below if gravity discharge is not possible.

* + 1. Where required, connect low elevations of [**foundation**] [**underslab**] subdrainage to stormwater sump pumps. Comply with requirements for sump pumps specified in Section 221429 "Sump Pumps."
  1. IDENTIFICATION

Retain this article for landscaping subdrainage only.

* + 1. Arrange for installation of green warning tapes directly over piping. Comply with requirements for underground warning tapes specified in specified in Section 312000 "Earth Moving."
       1. Install PE warning tape or detectable warning tape over ferrous piping.
       2. Install detectable warning tape over nonferrous piping and over edges of underground structures.
  1. FIELD QUALITY CONTROL

Retain first paragraph below to describe tests and inspections to be performed. Insert specific test requirements to comply with authorities having jurisdiction.

* + 1. Tests and Inspections:
       1. After installing drainage course to top of piping, test drain piping with water to ensure free flow before backfilling.
       2. Remove obstructions, replace damaged components, and repeat test until results are satisfactory.

See Section 01 40 00 – Quality Requirements for retesting and reinspecting requirements and Section 01 73 00 – Execution for requirements for correcting the Work.

* + 1. Drain piping will be considered defective if it does not pass tests and inspections.
    2. Prepare test and inspection reports.
  1. CLEANING
     1. Clear interior of installed piping and structures of dirt and other superfluous material as work progresses. Maintain swab or drag in piping and pull past each joint as it is completed. Place plugs in ends of uncompleted pipe at end of each day or when work stops.

END OF SECTION