SPECIFICATION FOR PREFABRICATED VERTICAL DRAIN

1.0 GENERAL

This work comprises of supply and installation of prefabricated vertical drains in accordance to the Specifications and Drawings.

2.0 MATERIALS

2.1 General Requirements

Prefabricated vertical drains (PVD) shall be of newly manufactured materials from an approved manufacturer and consist of a polymer core enclosed within an external non-woven filter jacket, and shall comply with the requirements as indicated in Tables 1a, 1b and 1c. For each type of drains to be used, the manufactured PVD to be used on site shall be subjected to all the tests specified in Tables 1a, 1b and 1c in independent laboratories approved by the Engineer. The types of PVD to be used at site shall be subjected to approval by the Engineer.

The filter jacket shall be capable of resisting all bending, puncturing and tensioning subjected during installation and design life of the drain.

The core shall be made of continuous plastic material fabricated to facilitate drainage along the axis of the vertical drain. The core shall be a profiled strip with or without perforation or a profiled mat with an open or closed structure.

The prefabricated vertical drain shall be resistant against rotting, mildew, bacterial action, insect, salts, acids, alkalis, solvent and other constituents in ground water.

2.2 Transportation and Storage

The vertical drain materials shall be labeled or tagged for sample identification and other quality control purposes. Each roll shall be identified by the manufacturer by lot number, individual roll number, date of manufacture, manufacturer and product identification of the jacket and core. Products without proper identification approved by the Engineer shall be rejected. If products that do not comply to this requirement were installed, the works shall also be rejected and necessary remedial works shall be carried out by Contractor to the satisfaction of the Engineer.

During transportation and storage, the drain shall be wrapped in heavy paper, burlap or similar heavy duty protection covering. The drain shall be protected from sunlight, mud, dirt, dust, debris and other detrimental substances during transport and on site storage.

All materials which are damaged during transportation, handling or storage and do not meet the minimum requirements of the vertical drain specifications shall be rejected by the Engineer. No payment of any kind shall be made on the rejected product.

2.3 Quality Control and Testing

The Contractor shall indicate the proposed source of the materials prior to delivery to site. The Contractor shall also submit samples and Manufacturer's certificates to verify the physical, mechanical and hydraulic properties of the drain to be used for Engineer's approval.

Prior to installation and at the discretion of the Engineer, an individual test sample shall be cut from at least one roll selected at random to represent each batch or every 100,000 metres,

whichever is lesser. Individual sample shall be not less than 3 metres in length and shall be full width. Samples submitted for tests shall indicate the linear metre of drain and manufacturer's identifications represented by the sample.

Table 1a: Properties of Prefabricated Vertical Drain

Properties	Test Designation	Required Value
Width (mm)	-	100 ± 2
Thickness (mm)	-	3 to 4
Tensile Strength of Drain (kN)	ASTM D4595-86	> 1.5 @10% strain
Elongation at Break (%)		≥ 2
Elongation at 0.5kN (%)	ASTM D4362	≤ 10

Table 1b: Discharge Capacity of Prefabricated Vertical Drain (ASTM D4716)

	Required Value
Discharge capacity for straight drain at hydraulic gradient i = 0.1 and 250kPa* (m^3/s)	≥ 50 x 10^{-6}
Discharge capacity for buckled drain at hydraulic gradient i = 0.1 and 150kPa* (m^3/s)	≥ 15 x 10^{-6}

**If (drain depth + 2 x fill height) > 25m but < 50m, pressure shall be 500kPa for straight drain and 350kPa for buckled drain.*

Table 1c: Properties of Filter Jacket

Properties	Test Designation	Unit	Required Value
Wide width tensile strength	ASTM D4595-86	kN/m	>2
Trapezoidal tear strength	ASTM D4533-91	N	>100
Grab strength	ASTM D4632	N	>350
Puncture resistance	ASTM D4833	N	>100
Burst strength	ASTM D3786-80a	kN/m^2	>900
Permeability at 100mm head	ASTM D4491	m/s	≥1x10^{-4}
Permitivity	ASTM D4491-92	s^{-1}	>0.4
Apparent pore size, O_{90}**	ASTM D4751-87	micron	<80
Mass to Area Ratio	Manufacturer	g/m^2	120

** Alternatively, O_{95} shall be < 90micron

Should any individual sample randomly selected fail to meet the specification, then that roll shall be rejected and two additional samples shall be taken at random from two other rolls representing the same batch on 100,000 metres. If either of these two additional samples fails to comply with the specification, then the entire batch of vertical drains represented by the samples shall be rejected.

3.0 INSTALLATION

3.1 Equipment

Prefabricated Vertical Drain (PVD) shall be installed with approved modern equipment of a type which will cause a minimum of disturbance of the sub-soil during the installation operation and maintain the mandrel in a vertical position. For penetration through stiff or difficult ground, the rig shall have additional hydraulic cylinders.

PVD shall be installed using a mandrel or sleeve and shall be inserted (i.e. pushed ~~or vibrated~~) into the soil. Vibration shall not be used in soft clay unless otherwise approved by the Engineer. The mandrel or sleeve shall protect the drain material from tears, cuts, and abrasion during installation, and shall be retracted after each drain is installed.

The size and shape of the mandrel or sleeve shall be as close as possible to the size and shape of the drains in order to minimise disturbance to the soil. The length of the mandrel shall be not less than the maximum length of the drain. The mandrel shall be capable of making a clean puncture through any geotextile if necessary.

Mandrel of Rhombic shape shall be used for soft clay unless otherwise approved by the Engineer. The mandrel or sleeve shall be provided with an anchor plate or similar arrangement at the bottom to prevent the soil from entering the bottom of the mandrel during the installation of the drain and to anchor the drain tip at the required depth at the time of mandrel withdrawal. The dimension of the anchor shall conform as closely as possible to the dimensions of the mandrel so as to minimize soil disturbance. The Engineer shall determine the acceptability of the anchorage system and procedure.

3.2 Approval

At least two weeks prior to the trial PVD installation, the Contractor shall submit full details of the materials, equipment, sequence and method of PVD installation to the Engineer for review and approval. Approval by the Engineer of installation sequence and methods shall not relieve the Contractor of his responsibility to install drains in accordance with the plans and specifications.

Prior to the installation of PVD, the Contractor shall demonstrate that the equipment, method, and materials produce a satisfactory installation in accordance with these specifications. For this purpose, the Contractor will be required to install two trial drains of approximately 16 linear metres at locations designated by the Engineer

Approval by the Engineer of the method or equipment used to install the trial drains shall not constitute, necessarily, acceptance of the method for the remainder of the project. If, at any time, the Engineer considers that the method of installation does not produce satisfactory PVD, the Contractor shall alter his method and/or equipment as necessary to comply with these specifications.

3.3 Installation Procedure

PVD shall be located, numbered and pegged out by the Contractor using a baseline and benchmark indicated by the Engineer. The Contractor shall take all reasonable precautions to preserve the pegs and is responsible for any necessary re-pegging. The as-built location of the PVD shall not vary by more than 150mm from the plan locations designated on the drawings.

PVD that are more than 150mm from design plan location or are damaged or improperly install, will be rejected and abandoned in place. PVD shall be installed from the working surface to the depth shown on the drawings, or to such depth as directed by the Engineer who may vary the depths, spacing, or the number of drains to be installed, and may revise the plan limits for this work as necessary.

During PVD installation, the Contractor shall provide the Engineer with suitable means of determining the depth of the advancing drain at any given time and the length of drain installed at each location.

The Contractor shall supply to the Engineer at the end of each working day a summary of the PVD installed that day. The summary shall include drain type, locations and length (to nearest 50mm) of PVD installed at each location.

Equipment for installing PVD shall be plumbed prior to installing each drain and shall not deviate from the vertical more than 1 in 50 during installing of any drain.

PVD shall be installed using a continuous push using static weight ~~or vibration~~.

Installation techniques using driving will not be permitted. Jetting techniques will be permitted only after receiving written approval from the Engineer

The installation shall be performed, without any damage to the drain during advancement or retraction of the mandrel. Alternate raising or lowering of the mandrel or "jerking" during advancement will not be permitted. Raising of the mandrel will only be permitted after completion of a drain installation. PVD not complying to the installation specified above shall be rejected. Replacement PVD at both side of rejected point shall be installed by the Contractor.

The mandrel penetration rate should be between 150mm and 600mm per second.

The completed PVD shall be cut off neatly 300mm above the working grade, or as otherwise specified on the contract drawings.

The Contractor shall observe precautions necessary for protection of any field instrumentation devices.

The Contractor shall replace, at his own expense, any instrumentation equipment that has been damaged or become unreliable as a result of his operations prior to continuing with drain installation or other construction activities.

3.4 Pre-augering/ Obstructions

The Contractor shall be responsible for penetrating any overlying material as necessary to install the drains.

Where obstructions are encountered below the working surface which cannot be penetrated by the installation equipment, the Contractor shall complete the drain from the elevation of the working surface to the obstruction and notify the Engineer prior to installing any more drains. At the direction of the Engineer and under his review, the Contractor shall attempt to install a new drain within 600mm horizontally from the obstructed drain. A maximum of two attempts shall be made as directed by the Engineer If the drain still cannot be installed to the design tip elevation, the drain location shall be abandoned and the installation equipment shall be moved to the next location, or other action shall be taken as directed by the Engineer

The Contractor shall be responsible for penetrating overlying fill material as necessary to satisfactorily install the PVD. Satisfactory installation may require clearing obstructions defined as any man-made or natural object or strata that prevents the proper insertion of the mandrel and installation of the PVD.

The Contractor may use augering, spudding, or other approved methods to loosen the soil and any obstruction material prior to the installation of PVD. The obstruction clearance procedure is subjected to the approval of the Engineer; however, such approval shall not relieve the Contractor of his responsibility to clear obstructions in accordance with the specification.

If augering is the selected method, the augers shall have a minimum outside diameter equal to the largest horizontal dimension of the mandrel, shoe or anchor, whichever is greater.

3.5 Splicing

Splicing of PVD drain material shall be done by stapling in a workmanlike manner and so as to ensure structural and hydraulic continuity of the drain. At the splice, upper portion of the jacket shall be external to the lower portion.

A maximum of 1 splice per drain installed will be permitted without specific permission from the Engineer

The jacket and core shall be overlapped a minimum of 150 mm at any splice.

3.6 Quantity Control

Full time supervision at site is important and necessary to prevent problems (e.g. cheating, wrong installation method, etc). There are various methods and mechanism to record the penetration length :

(i) Scale on the mast,
(ii) Dial Gauge (which need calibration), and
(iii) Automatic digital counter.

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