

# STANDARD SPECIFICATION FOR PREFABRICATED VERTICAL DRAINS

## Scope

The work covered under this specification includes the installation of Prefabricated Vertical Drains (PVD) at the locations shown on the plans and as directed by the Engineer.

## MATERIALS

Materials shall be CeTeau CT-D810, or approved equal. The drain should comply with the requirements indicated in Tables 1, 2 and 3.

Prefabricated Vertical Drains shall be of newly manufactured materials from an approved Manufacturer and consist of a polymer core enclosed within an external non-woven filter jacket. The filter jacket shall be capable of resisting all bending, punching and tensioning subjected during installation and the design life of the drain. The core shall be made of continuous plastic fabricated to facilitate drainage along the axis of the drain. The prefabricated vertical drain shall be resistant against rotting, mildew, bacterial or insect action, salts, acids, alkalis, solvents or other constituents in the ground water.

**Table 1: Properties of Prefabricated Vertical Drain**

<b>Properties</b>	<b>Unit</b>	<b>Test Designation</b>	<b>Required Value</b>
Width	mm	-	100mm (approx)
Thickness	mm	-	3mm (approx)
Tensile Strength of Drain	kN	ASTM D 1680	1.5
Elongation at Break	%	ASTM D 1680	≥ 2
Elongation at 1.0 kN	%	ASTM D1680	≤ 10

**Table 2: Discharge capacity of Prefabricated Vertical Drain**

<b>Description</b>	<b>Unit</b>	<b>Test Designation</b>	<b>Required Value</b>
Discharge capacity for straight drain at hydraulic gradient $i = 1.0$ and 250 kPa	m <sup>3</sup> /sec	ASTM D4716	$\geq 90 \times 10^{-6}$
Discharge capacity for buckled drain at hydraulic gradient $i = 0.1$ and 250 kPa	m <sup>3</sup> /sec	ASTM D4716	$\geq 15 \times 10^{-6}$

**Table 3: Properties of Filter Jacket**

<b>Properties</b>	<b>Unit</b>	<b>Test Designation</b>	<b>Required Value</b>
Wide width Tensile strength	Kn/m	ASTM D4595	> 5
Trapezoidal tear strength	N	ASTM D4533	> 100
Grab strength	N	ASTM D4632	> 350
Puncture resistance	N	ASTM D4833	> 100
Burst strength	kN/m <sup>2</sup>	ASTM D3786	> 900
Permeability at 100mm head	m/s	ASTM D4491	$\geq 1 \times 10^{-4}$
Permitivity	s <sup>-1</sup>	ASTM D4491	> 0.8
Apparent pore size, $O_{95}$	micron	EN ISO 12956	< 80

***Transportation and Storage***

The vertical drain material shall be labeled or tagged for sample identification and other quality control purposes. The Manufacturer shall identify each roll by individual roll number, date of manufacture and product identification of the jacket and core.

During transportation the drain shall be protected from sunlight, mud, dirt, dust, debris and other detrimental substances during transportation and storage on site.

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.

### ***Quality Control and Testing***

The actual vertical drain to be used shall be at the option of the Contractor subject to approval of the Engineer.

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 the Engineer's approval.

The Contractor shall submit a 1 m sample of the vertical drain material to the Engineer prior to usage and shall allow three weeks for the Engineer to evaluate the material. The sample shall be stamped or labeled by the Manufacturer as being representative of the drain material having the specified trade name. Approval of the sample material by the Engineer shall be required prior to site delivery of the drain material.

## **INSTALLATION**

### ***Equipment***

Where shown on the plans, or as directed by the Engineer, vertical drains shall be installed subsequent to the construction of the sand drainage blanked, and prior to placement of the surcharge material, or permanent embankment. The Contractor shall take all reasonable precautions to preserve the survey stakes.

Prefabricated Vertical Drain (PVD) shall be installed with approved modern equipment of a type, which will cause a minimum of disturbance to the soil during installation and maintain the mandrel in a vertical position. The PVD's shall be installed using a mandrel or sleeve that will be advanced through the compressible soils to the required depth using constant load, or constant rate of advancement methods only.

Prior to installation, the Contractor shall demonstrate that the equipment is in proper working condition, and provides a minimum of 15 ton of static push force when setting on firm ground. Hydraulic jetting shall not be permitted for installation of the drains, however limited amounts of water to lubricate the mandrel in highly plastic soils will be allowed with the Engineers approval.

The mandrel shall protect the PVD material from tears, cuts and abrasion during installation and shall be withdrawn after the installation of the drain. The drain shall be provided with an "anchor plate" or rod at the bottom of the mandrel to cover the mandrel end and prevent soil from entering the mandrel during installation. The anchor plate or rod shall be sufficient to anchor the drain at the required depth during mandrel removal. The mandrel shall be shaped to minimize disturbance to the soil, having a uniform and smooth exterior shape, without projections of any kind. The maximum projected cross sectional area shall be 80 cm<sup>2</sup>, including stiffening ribs.

### ***Datalogger***

Each rig should be equipped with a data monitoring system that records online the following parameters:

1. Installation date and time
2. Maximum installation force
3. Total length of drains installed
4. Number of drains installed
5. Installation depth per drain Penetration force per drain
6. Verticality of the leader

The monitoring system has to be positioned in the operator's cabin in order for the rig operator to use the data on the screen as a guideline for operations.

### ***Approval***

Four weeks prior to the beginning of trial PVD installation, the Contractor shall submit full details of the materials, equipment, sequence and method proposed for PVD installation to the Engineer for review and approval.

The submittal shall at the minimum contain the following specific information :

1. Size, type, weight, maximum pushing force, and configuration of the installation rig
2. Dimensions and length of mandrel
3. Details of drain anchorage
4. Data Logger specifications
5. Detailed description of proposed installation procedures
6. Proposed methods for overcoming obstructions
7. Proposed methods for splicing drains

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 production installation 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 2 trial drains at locations designated by the Engineer. Trial drains will be paid at the contract unit price unless the drain is improperly installed.

Approval by the Engineer of the method or equipment used to install the trial drains shall not constitute, necessarily, acceptance for the remainder of the

project. If, at any time, the Engineer considers that the method of installation does not produce a satisfactory installation, the Contractor shall alter his method and/or equipment as necessary to comply with these specifications.

### ***Installation Procedure***

Prefabricated vertical drains shall be located, numbered, and staked (or located by other suitable means) by the Surveyor using a baseline and benchmark indicated by the Engineer. The Contractor shall take all reasonable precautions to preserve stakes (or other markers) and is responsible for any necessary relocation of marking devices. The as-installed location of the PVD's shall not vary by more than 150 mm from the plan locations designated on the drawings.

Drains that are more than 150 mm (6 inches) from design plan location or are damaged or improperly installed shall be rejected and abandoned in place.

PVD's 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's, or the number of drains to be installed, and may revise the plan limits for this work as necessary.

Drains may be terminated if refusal is encountered at a depth less than design depth. The refusal length of each drain may vary based on the geological formations encountered over the site. Refusal shall be defined as installation of the drain to the non-compressible layer underlying the compressible layer to be consolidated. Through the use of the soils logs taken at the project site the Engineer shall define the compressible layer versus the non-compressible layer. The PVD installation equipment will indicate refusal when the tip of the mandrel meets resistance and stops or slows at the approximate depth of the non-compressible layer. The finished depth of the drain shall not extend more than 0.3 m into the non-compressible layer.

During 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 the drain installed at each location. The drain material shall be cut neatly at its upper end with 100 mm to 200 mm protruding above the working surface. If the PVD is to connect to prefabricated horizontal drainage system, sufficient PVD material shall be left to make the connection.

The Contractor shall supply to the Engineer at the end of each working day a summary of the total amount of PVD installed that day.

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 installation of any drain.

The installation shall be performed without any damage to the drain during advancement or retraction of the mandrel. In no case will alternate raising or lowering of the mandrel during advancement be permitted. Raising of the mandrel will only be permitted after completion of a drain installation.

Installation of the drains should be coordinated with the placement of geotechnical instrumentation as shown on the plans. Special care should be taken to install drains in such a manner so as not to disturb instrumentation already in place. The replacement of instrumentation damaged or rendered nonfunctional as a result of the Contractor's activities will be the responsibility of the Contractor.

### ***Experience***

As a minimum experience requirement, the Contractor shall have successfully completed five prefabricated vertical drain installation projects of similar size and depths totaling no less than 1,000,000 linear meter installed. The five projects shall be identified by project name, location, project description, size, completion date, and contract manager.

### ***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 600 mm 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 paid for all obstructed drains at the contract unit price, less any allowance for drain above the working surface, unless the drain is improperly installed.

The Contractor shall be responsible for penetrating overlying fill material as necessary to satisfactorily install the PVD. The Contractor may use augering, spudding, or other approved methods to loosen the soil and any obstruction material prior to installation of the PVDs. The procedure for penetrating such material shall be at the approval of the Engineer; however, such approval shall not relieve the Contractor of his responsibility to clear obstructing material in accordance with these specifications.

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. Augering shall not extend more than 0.3 m into the underlying compressible material. Augers or spuds must be capable of penetrating 40 ft. below the working surface to facilitate the installation to the depths shown on the plans.

### ***Splicing***

Splicing of the PV drain material shall be done by stapling in a workmanlike manner so as to ensure structural and hydraulic continuity of the drain. At the splice, the jacket that passes through the installation rig first shall be external to the trailing portion.

A maximum of one splice per drain will be permitted without specific permission from the Engineer. The jacket and core shall be overlapped a minimum of 150 mm at any splice.

### ***Drain Cuts***

When the drain material snaps during installation, the mandrel will be retrieved and the drain material will be guided again through the mandrel. A new drain will be installed at the same position.

## **PAYMENT**

### ***Method of Measurement***

Prefabricated vertical drains will be measured by the linear meter for the full length of the drain complete and in place including required PVD material extending above the working platform.

### ***Basis of Payment***

Payment for prefabricated vertical drains shall be made at the contract unit price per linear meter (foot), which price shall be full compensation for the cost of furnishing the full length of the drain material, installing the drain, altering of the equipment and methods of installation in order to produce the required end result in accordance with the plans and specifications, and shall also include the cost of furnishing all tools, materials, labor, equipment and all other costs necessary to complete the required work, including augering or spudding to facilitate installation. No direct payment will be made for unacceptable drains or for any delays or expenses incurred through changes necessitated by improper or unacceptable material or equipment, but the costs of such shall be included in the contract unit price for this work.