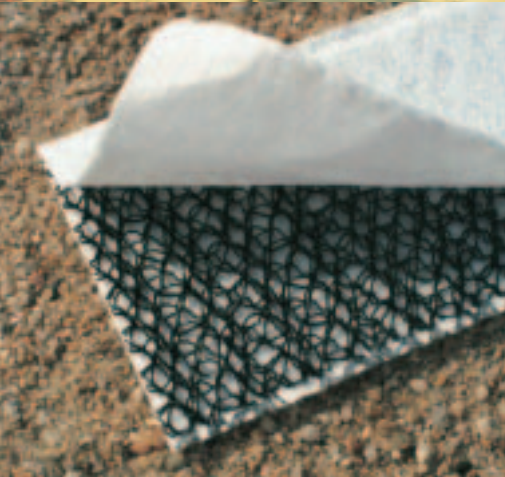




Colbondrain®

SOIL IMPROVEMENT



COLBOND

Colbond

Colbond is a leading producer of high-quality synthetic nonwovens for flooring, automotive, and construction applications, and three-dimensional polymeric mats and composites for civil engineering, building and industrial applications. Colbond employs some 650 people worldwide and is headquartered in Arnhem, the Netherlands, with production facilities in Emmen and Arnhem (NL), Obernburg (D), and Asheville (NC, USA). Regional sales offices are located all over the world.

The range of specialty geosynthetic products for civil engineering includes *Enkamat*[®], *Enkadrain*[®], *Enkagrid*[®], *Colbondrain*[®] and *Armater*[®]. These products are used all over the world for erosion control, drainage, waste containment, soil reinforcement, stabilization and consolidation.

ISO 9001

The Quality Management of Colbond at Arnhem and Obernburg (development, production and sales) has been approved by Lloyd's Register Quality Assurance to the NEN-EN-ISO 9001:2000 Quality Management System Standard (Certificate No. 935136).



CE Certification

Colbondrain CX 1000 is CE-certified by an independent notified body (Certificate No. 0799-CPD).



Proven performance

Data from computer studies, laboratory tests and full scale field trials conducted by Delft Geotechnics, Geosyntec Consultants and Colbond Geosynthetics Research Laboratories have been used to design Colbondrain PVD. Until today more than 200 million linear meters of Colbondrain have been installed worldwide. Colbond is one of the leading suppliers of vertical drains in the world.

Colbond bv
P.O. Box 9600
6800 TC Arnhem
The Netherlands
Tel.: +31 26 366 4600
Fax: +31 26 366 5812
E-mail: geosynthetics@colbond.com
Internet: www.colbond.com

Colbond
510, Thomson Road # 17-00
298135 Singapore
Tel.: +65 6 258 1333
Fax: +65 6 259 8607
E-mail: colbond@singnet.com.sg

The information set forth in this brochure reflects our best knowledge at the time of issue. The brochure is subject to changes arising from new developments and findings; the same applies to our products. We undertake no liability for the results of usage of our products and information.

CD-02-GB-A-09/2004

© Colbond

® Registered trademark

Printed in The Netherlands

COLBOND

Colbondrain[®] prefabricated vertical drain

Accelerated consolidation

The very slow consolidation of soft cohesive clays - a process which often requires up to 20 to 25 years to achieve 90% consolidation - is a problem of increasing importance.

With Colbondrain prefabricated vertical drain (PVD), Colbond provides an economical solution to this issue (figure 1).

The principle feature of Colbondrain lies in providing much shorter and

highly permeable drainage paths for the dissipation of excess porewater pressure, allowing 90% consolidation in a time period of months, rather than years (figure 2).

This substantial reduction of the consolidation time required for compressible clay, leads to a higher factor of safety and a shorter construction time of the final works, in turn resulting to a reduction of project costs to the client.

Figure 1 Without vertical drains

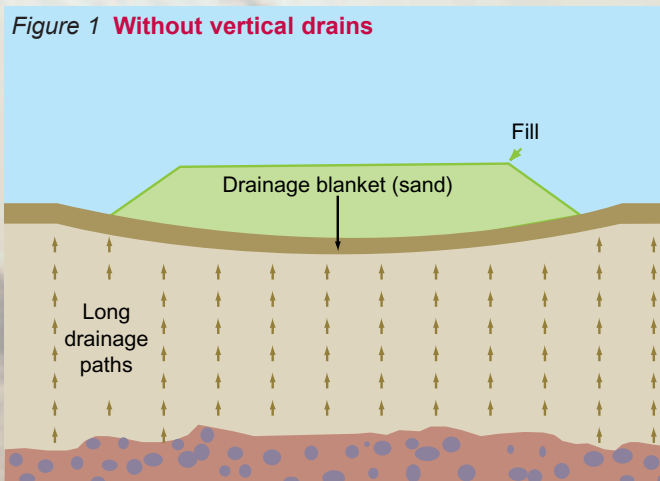
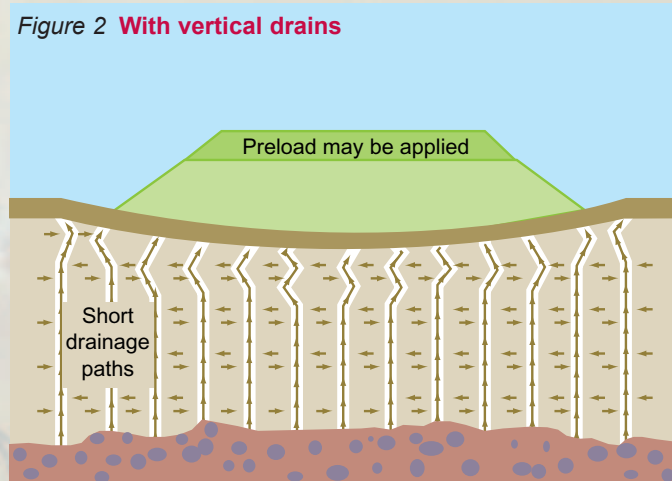


Figure 2 With vertical drains



Reclamation area, Haneda Airport, Japan



Changi Airport, Singapore

High performance construction

Colbondrain consists of a nonwoven polyester filter jacket and a 3-D open core of thick polyester monofilaments, fused at the point of intersection. As a result of this unique core all space within the core structure is fully interconnected for maximum efficiency of water discharge. This high discharge rate is maintained even when Colbondrain is buckled more than 90° by the consolidation settlement which can result in about 50% compression in the upper clay layers. The nonwoven polyester filter jacket exhibits optimum performance of filtration, permeability and stiffness. The ultrasonic welding of the filter to the filament core at the edges of Colbondrain ensures the filter is kept tight across the core. Consequently no loose filter material can be pushed into the core structure and reduce the flow capacity.

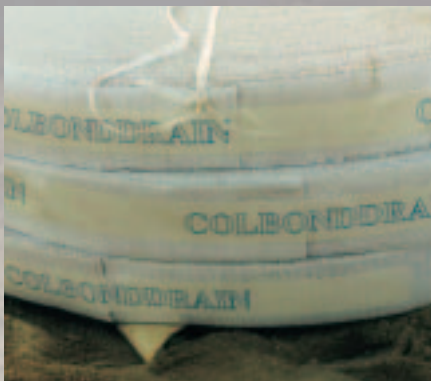
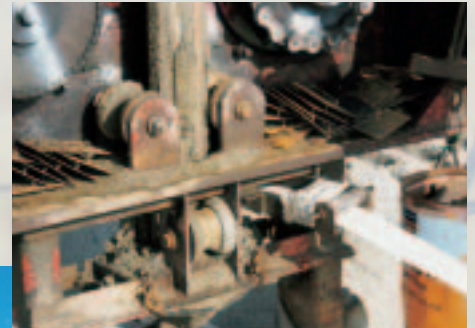
Installation

The usual installation equipment is a purpose manufactured, 20 - 30 meter high leader, mounted on a 40 ton hydraulic excavator. The leader contains a steel rhombic mandrel which carries the PVD to a depth not exceeding the mandrel length.

A rhombic mandrel is normally used to minimize disturbance of the ground and to reduce the effects of smear. When the compressible clay is very deep and/or contains gravel bands, special techniques may be used such as vibrators and heavy mandrils. Because of the advanced qualities Colbondrain is often the chosen PVD for major, technically demanding projects, such as the third runway at Changi Airport, Singapore. In this project Colbondrain has been installed to depths of up to 50 meters.

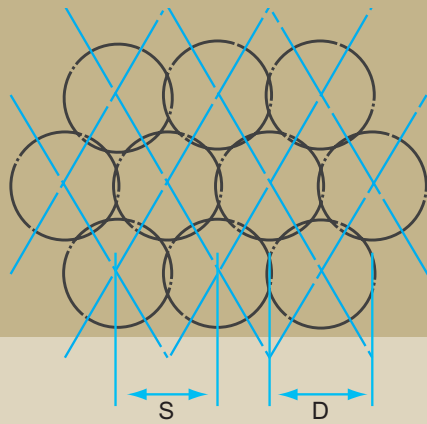
The project required a total of 60 million linear meters of PVD and is probably the largest vertical drain reclamation project in the world.

Rhombic mandrel for minimum soil disturbance



Three rolls of Colbondrain in a pack

Rapid installation



Triangular grid layout

Hence $D = 1.05 S$

S = spacing of the drains

D = diameter of the equivalent cylindrical column of soil, drained by each drain



Rapid installation

Vertical drain design

An assessment of the effect of vertical drains on the consolidation process can easily be made using a method first proposed by Kjellman and is shown in equation form below:

$$t = \frac{D^2}{8C_h} \left[\ln \left(\frac{D}{d} \right) - \frac{3}{4} \right] \ln \frac{1}{1-U_h}$$

t = consolidation period (year)

D = diameter of drained soil cylinder (m)

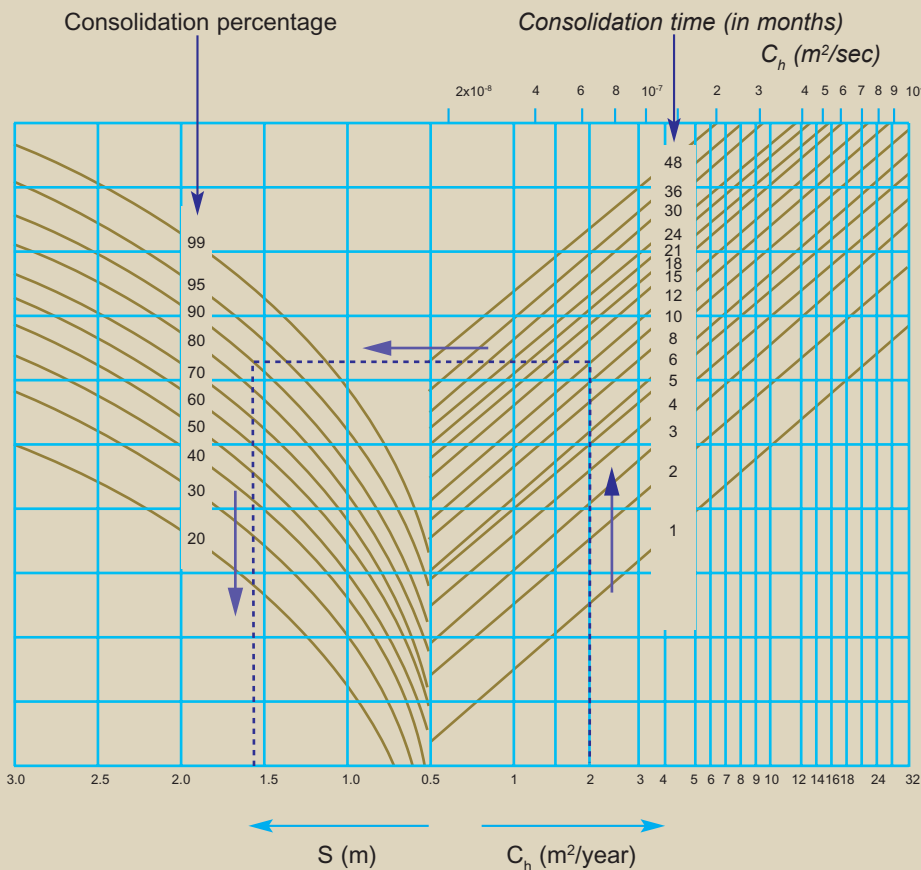
C_h = horizontal coefficient of consolidation ($m^2/year$)

d = equivalent diameter of PVD (m)

U_h = average degree of consolidation

The equation has been developed into a design chart which relates the degree of consolidation, time available for consolidation, coefficient of consolidation (C_h) and thus the required drain spacing (S) can be determined assuming the normal triangular grid of drain installation.

The use of a triangular grid for installation gives the most efficient relationship between the area of a soil cylinder with diameter D served by a drain and the area of an equilateral triangle of side length S representing the grid spacing.



Design chart for Colbondrain CX 1000/10

Reference: Elzen, L.W.A. van den (1982), "Accelerated consolidation of compressible, low-permeable subsoil by means of Colbondrain"