# Safety Selection and Application of Geosynthetics for Civil Engineering Projects

Geotextile Introduction and Site Application

– An Extension Of HKIE / Civil Division Webinar (2023-02-15)

– Webinar On Reclamation In Hong Kong – Sixty Years Of Development In Tseung Kwan O

# Abstract

Geosynthetics materials have been widely used in civil engineering projects in Hong Kong for many years. This presentation aims to provide a brief introduction on the fundamental concepts and functions of geosynthetics and the types of products with different properties to fulfill the need in the industry. The selection and installation processes, with reference to completed international and local projects, will be discussed from the perspectives of manufacturers and experienced supervisory staff. This presentation will also demonstrate how manufacturers and front-line personnel could collaboratively work out and modify methods to solve practical problems encountered during construction.

## Biographies of Speakers:

- Mr. CHENG Tak Sum

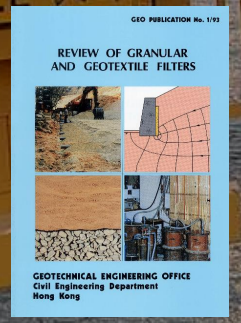
  Mr. CHENG has 54 years' site working experience in different aspects of the civil engineering industry in Hong Kong. He has served as Site Agent and Construction Manager for several international contractors. He has participated in many prestigious projects like Tuen Mun Check lap Kok Link Sub Sea Tunnel, Anderson Road Quarry Development, and Fanling Highway Widening. He is familiar with different techniques in reclamation and is recognized as an expert in this field. Mr. CHENG has been actively engaged as speaker in numerous technical seminars, organized by professional bodies, to share his experience, and receives well response. His contribution to the industry is honorable to many consultants and fellow engineers.

- Mr. Wilson FUNG

  Mr. FUNG is the Founder of Well Group Hong Kong Ltd., he has 25 years of experience in supplying engineering products, namely Blackhall Guard Valve, Reservoir Discharge Valve, GrandApex HDPE pipe and fitting with welding equipment tools, Itron AMR Water meter and wireless communication system. Mr. Fung is also the sole distributor of Tencata Geosynthetics, together with the overseas manufacturer they developed a soil/ water separator by using Geobag® made from geosynthetics for the Third Runway Project in Hong Kong.

# Function of This Presentation

- 1. Page number – Pls drop down the page number for Q&A
- 2. QR code for reference
- 3. Q&A

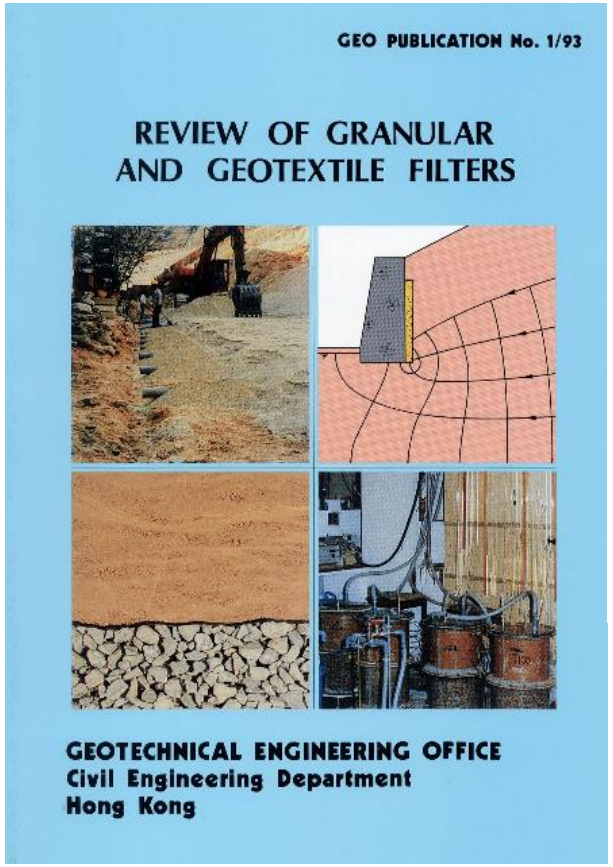


*GEOSYNTHETICS* can be simply defined as

*SYNTHETIC MATERIALS* used for

*GEO-ENGINEERING* applications

# Application of Filter in Hong Kong





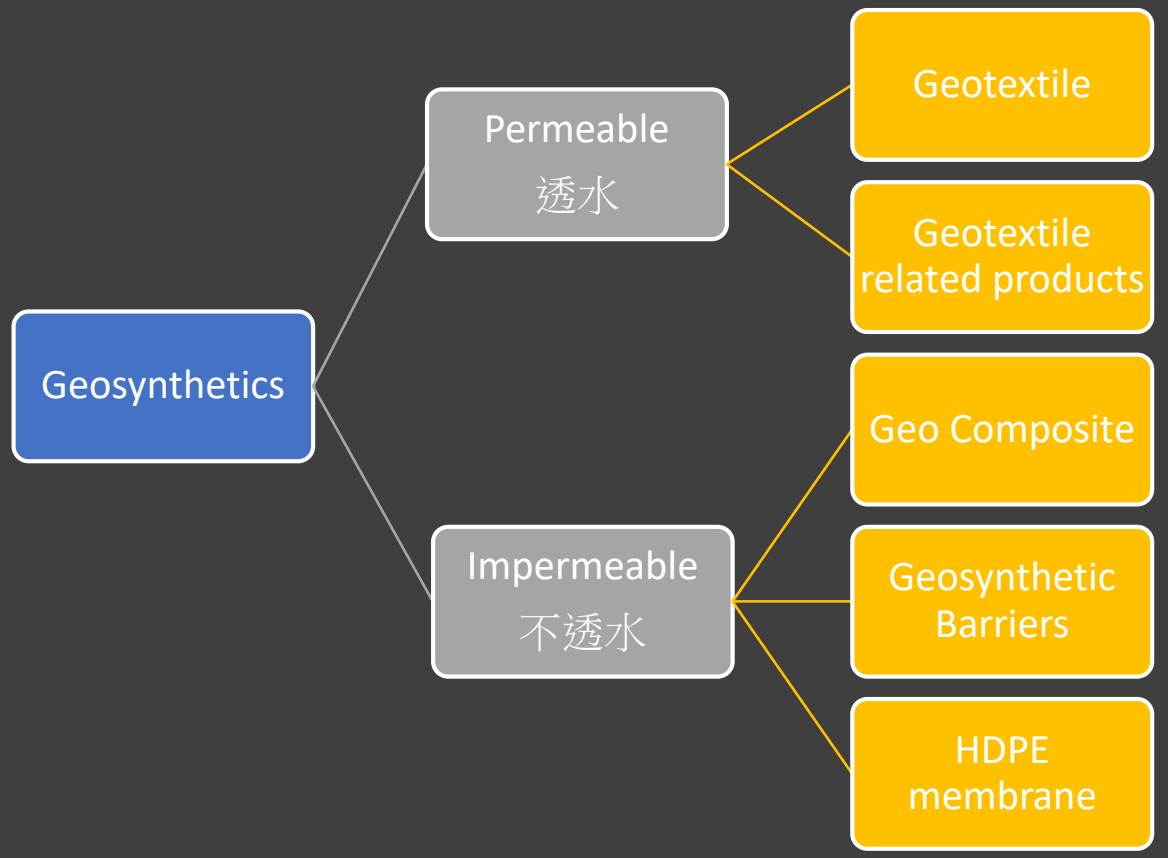

## 2. FILTER APPLICATION AND PERFORMANCE CRITERIA

### 2.1 APPLICATION OF FILTERS IN HONG KONG

Filters have a wide range of applications in civil engineering. In Hong Kong, they are commonly incorporated in slope works and behind retaining walls as part of the subsurface drainage system. Their functions are to prevent internal erosion during movement of water from the base soil through the filter to the drainage outlet and to permit the unimpeded flow of water within the drainage system (Figures 1 and 2).

The two types of filters in common use are granular filters and geotextile filters. In Hong Kong granular filters generally consist of graded crushed rock products, whereas geotextile filters are permeable textile fabrics.

# Definition of Geosynthetic



# Geosynthetics : Raw Materials

- PVC (polyvinyl chloride-聚氯乙烯) began commercial production in 1933
- LDPE (low density polyethylene -低密度聚乙烯) in 1939
- PA (polyamide) commonly known as Nylon, in 1939
- PET (polyester -聚酰胺) in 1953
- HDPE (high density polyethylene,高密度聚乙烯) in 1955
- PP (polypropylene,聚丙烯) in 1955

- Today,
  - PP dominates geotextile production
  - PET dominates high strength , low creep reinforcement geotextile production
  - PVC and PE dominates geomembrane production

# What is PET and PP?

## Polyester (PET)

- Absorbs some amount of water
- materials are highly used in textile industry
- properties such as high strength, high durability, hydrophobic nature and quick drying
- **Hydrophobic nature - Those that naturally repel water, causing droplets to form**

## Polypropylene (PP)

- Does not absorb water
- major application as a packaging material
- considered as a tough material. It is also highly resistant to electricity. So it is a good electrical insulator.
- Polypropylene is a thermoplastic polymer material that has applications as fibers and plastics.
- Thermoplastic (Polymer can be melted) e.g PE, PVC, PP, PA (Nylon)

# Geosynthetics – General Production Method

## Geotextile

- Weaving編織
- Knitted針織的
- Heat Bonded熱粘合
- Needle Punched針刺
- Chemical bonded化學結合

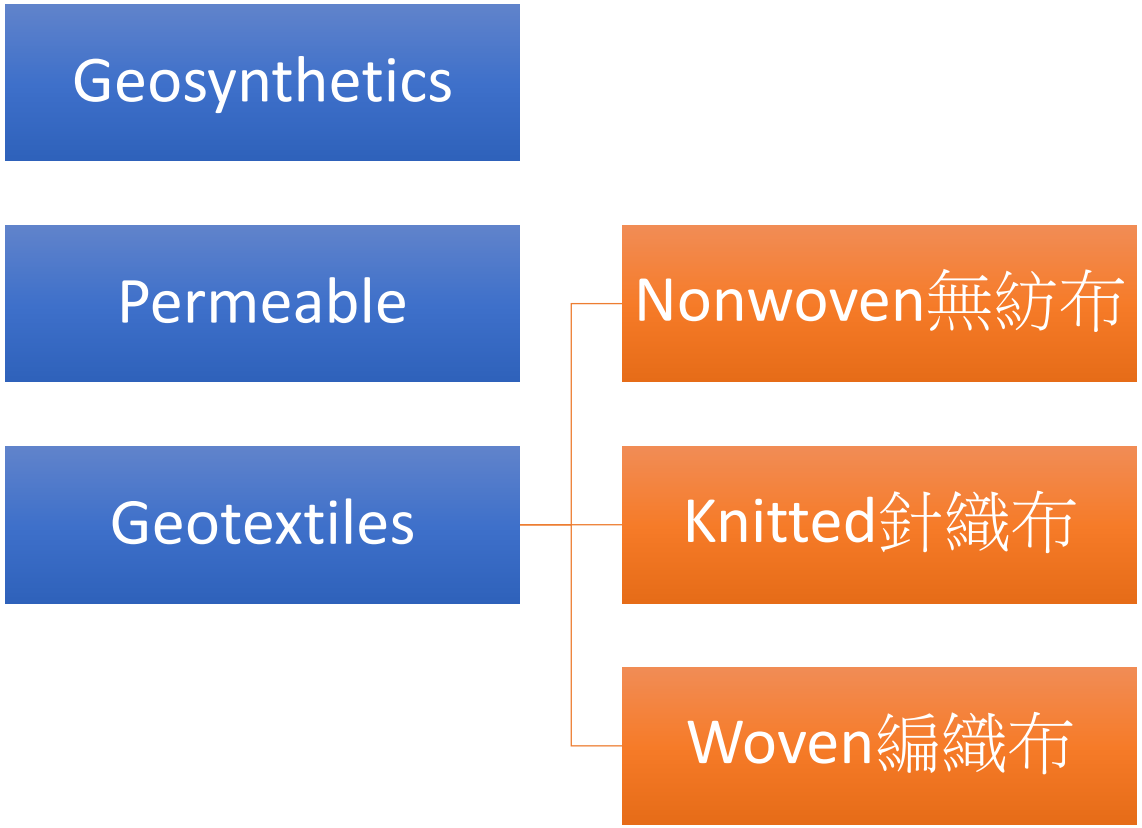
## Geotextile related Product

- Weaving
- Knitted
- Heat-bonded
- Needle Punched
- Chemical bonded

## Geosynthetic Barrier

- Needle Punched
- Chemical Bonded
- Extruded擠壓

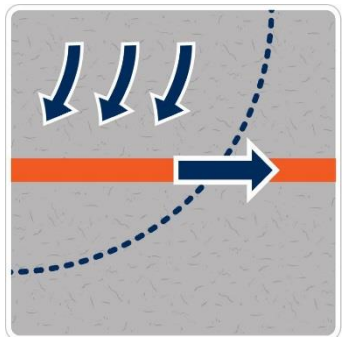
# Geotextile Definition



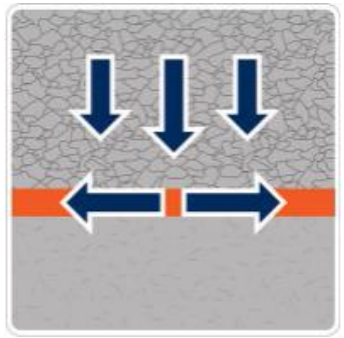

- Planar, Permeable, polymeric (synthetic or natural) textile material, which may be non-woven, knitted, or woven, used in contact with soil and / or other material in geotechnical and civil engineering application – we can call it Geotextile
- 平面的、可滲透的、聚合的（合成或天然的）紡織材料，可以是無紡布、針織物或編織物，用於與土壤和/或岩土工程和土木工程應用中的其他材料接觸——我們可以稱之為土工布

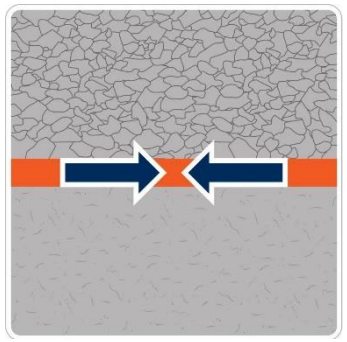
# The Fundamentals Function of Geosynthetics

## Functions

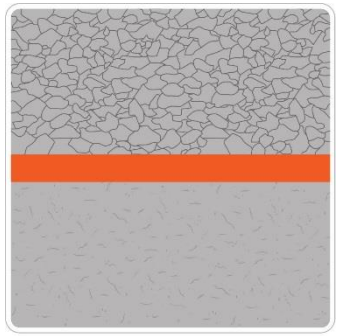


REINFORCEMENT



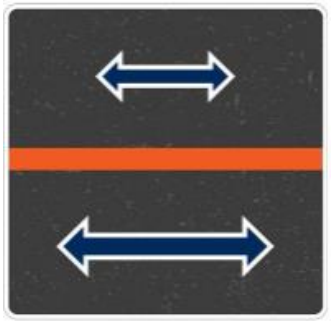


CONFINEMENT



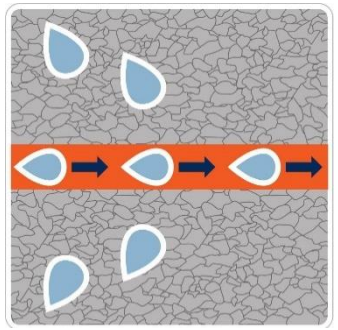
SEPARATION

PROTECTION

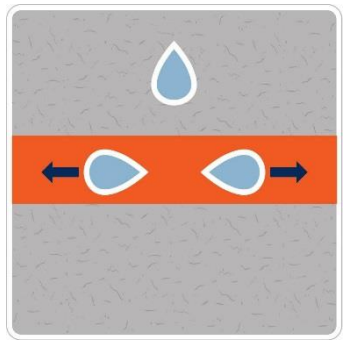


STRESS RELIEF

FILTRATION

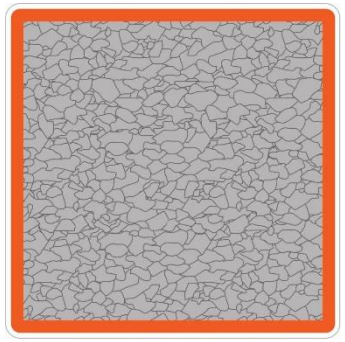


DRAINAGE (Vertical or Horizontal)



MOISTURE MANAGEMENT

SURFACE EROSION CONTROL

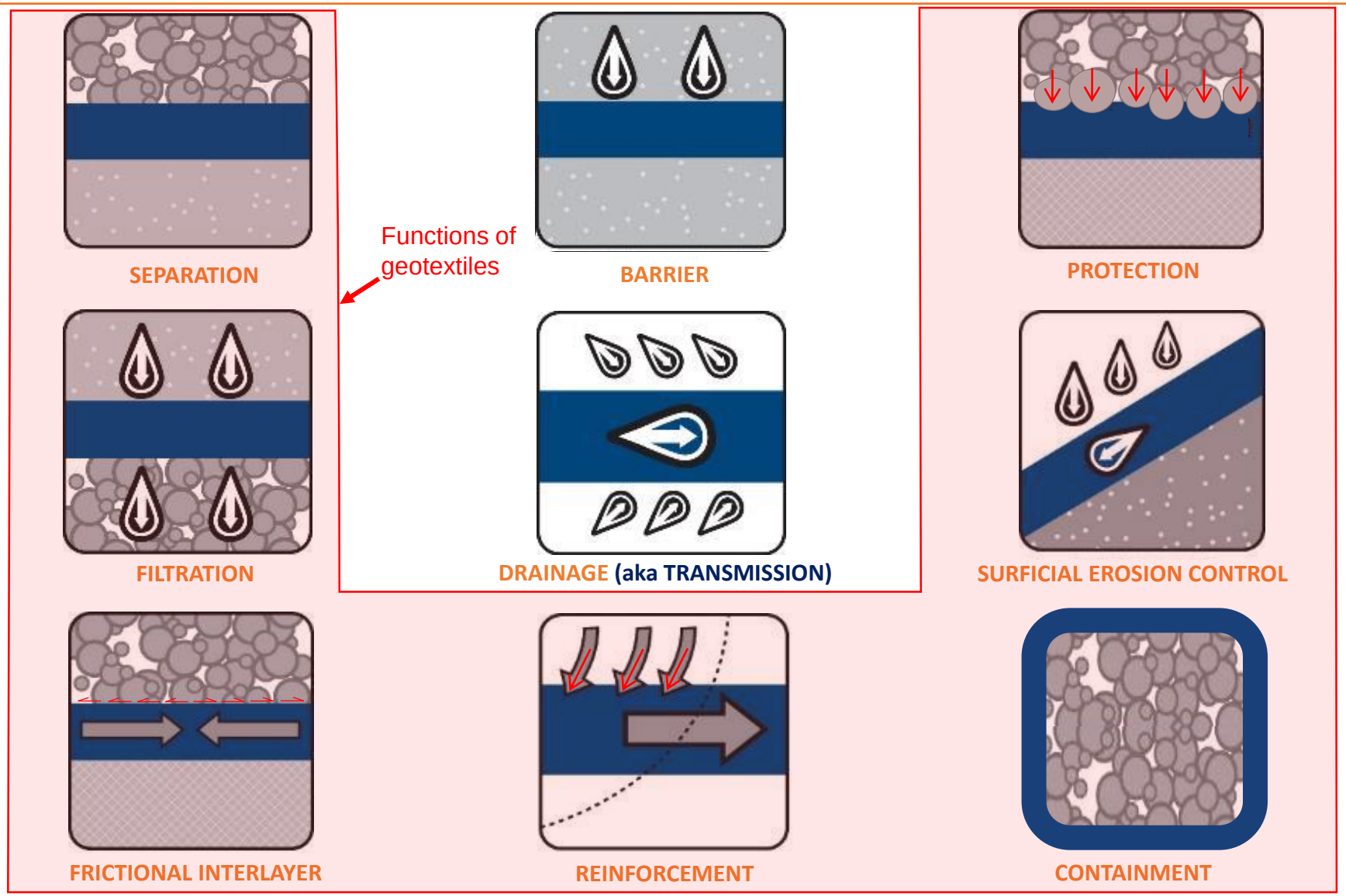


CONTAINMENT

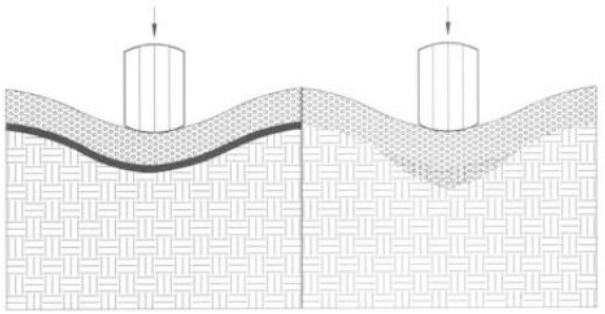
BARRIER

# Functional Application

## Functions of geosynthetics

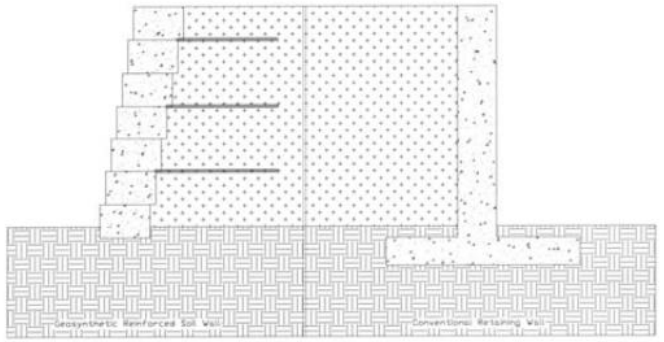


## SEPARATION



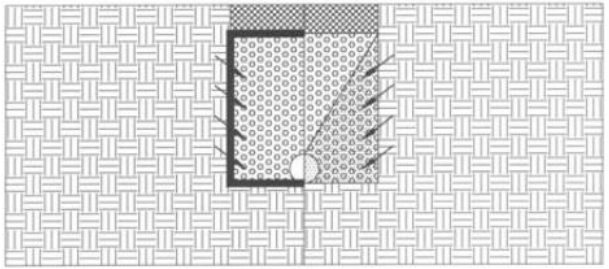
With a Geotextile  Without a Geotextile

## REINFORCEMENT



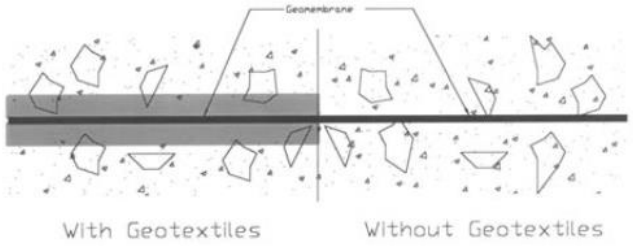

With Geotextiles  Without Geotextiles

## FILTRATION



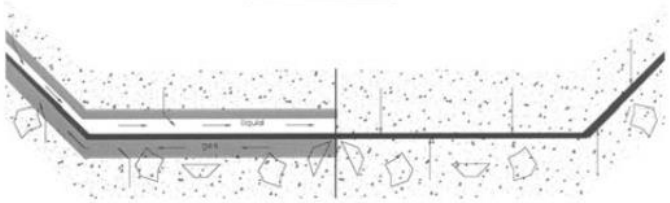
With Geotextile  Without Geotextile

## PROTECTION/CUSHION



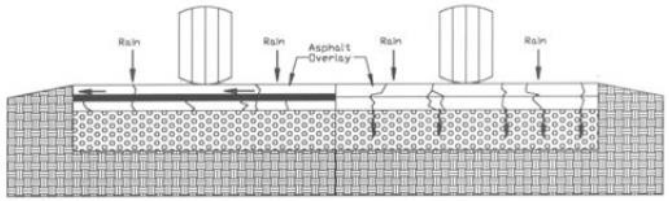

With Geotextiles  Without Geotextiles

## PLANAR FLOW




With Geotextiles  Without Geotextiles

## FLUID BARRIER




With a Paving Fabric  Without a Paving Fabric

# Standards We Need to Look At

**Properties of Polyfelt® TS Nonwoven Geotextiles**

| Property | Test Standard | Unit | TS 20 |
|---|---|---|---|
| Physical characteristics | | | |
| Polymer | | | |
| UV resistance | | | |
| tensile strength retention | ISO 10319 | | |
| puncture strength retention | ISO 12236 | | |
| Chemical resistance | | | |
| Tensile strength (avg.) | ISO 10319 | kN/m | 9.5 |
| Tensile elongation (MD/CD) | ISO 10319 | % | 75/35 |
| Performance energy* | Calculated | kN/m | 2.5 |
| CBR puncture strength | ISO 12236 | N | 1500 |
| Effective opening size $O_w$ | ISO 12956 | mm | 0.12 |
| Vertical water flow (50mm head) | ISO 11058 | l/m²/s (mm/s) | 115 |
| Horizontal water flow (20 kPa) | ISO 12958 | l/m.h | 4 |
| Horizontal water flow (200 kPa) | ISO 12958 | l/m.h | 1.4 |
| Nominal mass | ISO 9864 | g/m² | 125 |
| Thickness (2 kPa) | ISO 9863 | mm | 1.2 |

# Tensile Test Equipment – ISO 10319

Geotextile Standard AS 3706.2 – Method B – Brab tensile test Method

# BS EN 10139:2015 Page 4

Make sure your test sample width is greater than the length of the specimen

The basic distinction between the current method and other methods for measuring tensile properties of fabrics is the width of the specimen. In the current method, the width is greater than the length of the specimen, as some geosynthetics have a tendency to contract (neck down) under load in the gauge length area.

The greater width reduces the contraction effect of such fabrics and provides a relationship closer to the expected fabric behaviour in the field, as well as a standard for comparison of geosynthetics.

When information on strain is required, extension measurements are made by means of an extensometer, which follows the movement of two reference points on the specimen. These reference points are situated on the specimen symmetry axis, which is parallel to the applied load, and are separated by a distance of 60 mm (30 mm on each side of the specimen symmetry centre). This distance can be adapted for some types of geogrid in order to include at least one row of nodes or internal junctions.

# Puncture Test – ISO 12236

3/9/23

Page 15 Standard Page

BRITISH STANDARD

BS EN ISO 12236:2006

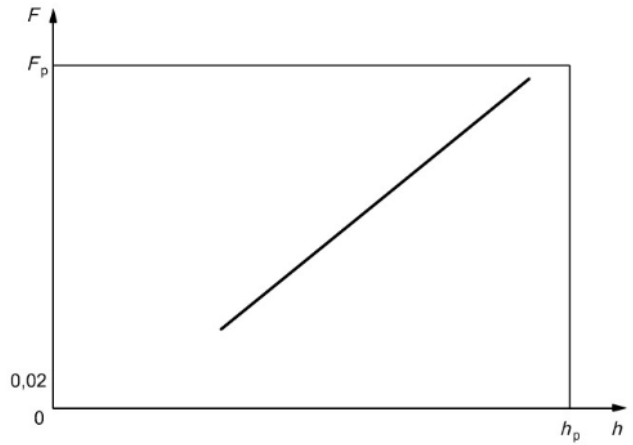
## Geosynthetics — Static puncture test (CBR test)

# ISO 12236 – Puncture Test

**3.4**
**push-through displacement**
$h_p$
displacement at maximum recorded force $F_P$

See Figure 1.

NOTE The push-through displacement is measured in millimetres.

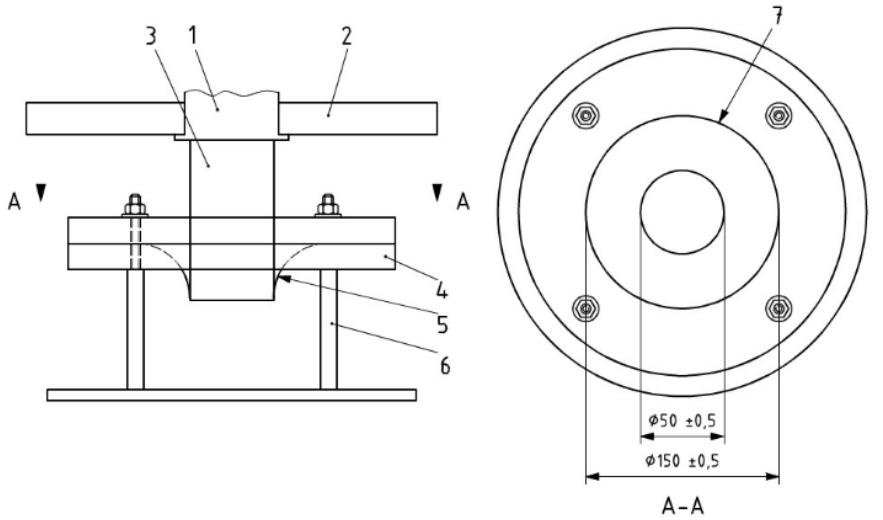



**Key**
$h$ displacement, in mm
$F$ plunger force, in kN
$F_p$ push-through force, in kN
$h_p$ push-through displacement, in mm

**Figure 1 — Example of a typical curve — Plunger force versus plunger displacement**



Dimensions in millimetres




**Key**
1 load cell
2 cross head
3 plunger
4 clamping rings
5 specimen
6 support frame or CBR mould
7 rounded inside edges

**Figure 3 — Example of clamping system device**




# Effective Opening Size – ISO 12956

# What is $O_{90}$ Means ?

The different methods developed for the measurement of AOS, as summarized in Table 6, can produce very different results. For example, the opening size $O_{90}$ ($O_m$ being the size at which m% by weight of particles are retained on the geotextile) of a needle-punched geotextile tested by the GEO using dry sieving for the sand fractions, was twice the opening size given by the geotextile manufacturer, which was obtained by performing hydrodynamic sieving. A similar discrepancy for a heat-bonded geotextile was also found in the test, but in this case the method used by the manufacturer was also dry sieving. While the appropriate range and limitations of each test method are given in Table 6, there is clearly a need to establish further guidelines on the suitability of the test methods for different types of geotextiles. It appears that dry sieving is applicable to woven, knitted, stitch-bonded and thin nonwovens, while hydrodynamic sieving is more appropriate for thick needle-punched nonwovens. However, the latter test generally is considered to be superior in modelling the field hydraulic condition and has the advantage of being able to determine smaller geotextile opening sizes.

Page 15 Standard Page

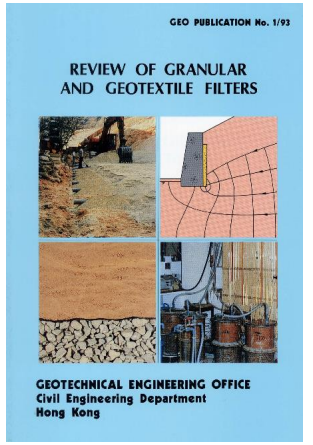
Dear Mr. Ng:

Thank you for consulting TRI/Environmental, Inc. (TRI) for your geosynthetics testing needs. TRI is pleased to submit this final report for laboratory testing.

| | |
|---|---|
| TRI Job Reference Number: | E2310-06-02 |
| Material(s) Tested: | [redacted] Woven Geotextile(s) |
| Test(s) Requested: | CBR Puncture Strength (ISO 12236)<br>Apparent Opening Size (ISO 12956 - Wet Sieving)<br>Permittivity (ISO 22058)<br>Wide Width Tensile Properties (ISO 10319) |

If you have any questions or require any additional information, please call us at 1-800-880-8378.

Sincerely,




! Test the Sample **Before Use** !

AOS-Apparent Opening Size ( page 47 chapter 9)

Table 6 - Different Methods for the Measurement of Geotextile Opening Size

| Method and Brief Description | Measure of Geotextile Apparent Opening Size (AOS) | Remarks |
|---|---|---|
| *Visual Means* (Calhoun, 1972) : Direct measurement made from a magnified image of the geotextile projected on a screen with the use of a light source | $O_{95}$, also known as Effective Opening Size (EOS) | Only applicable to geotextiles with fairly uniform and well defined openings, e.g. woven monofilaments. Appropriate for opening sizes down to about 100 microns. Not suitable for nonwovens. |
| *Dry Sieving* (also known as Reverse Sieving): Measurement of the opening size distribution made by sieving particles of known size range through the geotextile using vibratory sieving equipment. | | Applicable to a wide range of woven and nonwoven geotextiles but limited by the smallest size particle fraction that can be sieved. Not a problem for wovens as $O_{90}$ is generally greater than 100 microns. Extrapolation normally used for nonwovens with $O_{90} < 75$ microns; not normally used for $O_{90} < 50$ microns. Results are sensitive to test apparatus (e.g. sample holder) and test conditions, such as characteristics of vibration (frequency and direction), temperature and humidity. Reproducibility of results between laboratories not proven (Fayoux et al, 1984). |
| (a) Dry sieving using sand fractions (Ogink, 1975 ; Schober & Teindl, 1979) | $O_{90}$ is taken as the size at which 90% by weight of particles are retained on the geotextile. | Use of particles finer than 60 microns not recommended as interparticle forces can affect results (Lawson, 1984). |
| (b) Dry sieving using "ballotini" (spherical glass beads) (McKeand, 1977, Ruddock, 1977, USCE, 1977) | $O_{90}$, as above, or $O_{95}$ (EOS) taken as the sieve size at which 5% by weight of particles passes the geotextile (USCE, 1977). | Minimum size of commercially available ballotini is about 70 microns (Lawson, 1984). Anti-static device required to neutralize build-up of static electricity. Ballotini may break as a result of repeated use and their sizes have to be checked regularly. |
| *Wet Sieving* (Heerten, 1981, 1982) : Sand sample sieved through geotextile using modified vibratory sieving equipment with water spraying at regular intervals. | $D_w$ calculated using specified relationship (see Van Zanten, 1986). | Limited number of sieves used, resulting in large gaps in values of $D_w$. Different quantity of sand used for testing nonwovens and wovens, making it difficult to compare results (John, 1987; Van Zanten, 1986). |
| *Hydrodynamic Sieving* (Fayous, 1977, CFGG, 1984) : Sand sample supported by the geotextile is repeatedly immersed in water at a specified frequency for a period of about 24 hours, then the grading of the soil passing the geotextile is determined. | $O_f$, also known as the filtration diameter, is taken as the $D_{95}$ of the soil that has passed the geotextile. | Considered to model field conditions better than dry sieving : reproducibility of results between laboratories reportedly satisfactory (Fayoux et al, 1984). Alternating water flow encourages the formation of a natural filter above the geotextile. $O_f$ found to be smaller than opening sizes obtained by dry sieving or wet sieving (Faure et al, 1986b). Appropriate for opening sizes $O_f$ down to 30 microns. Time consuming to perform. |
| *Suction Method* (Andrei et al, 1982, Dennis & Davies, 1984, Paute & Chene, 1977) : Pore size distribution of the geotextile estimated using a capillarity model which relates the volume of water retained in the pores of the geotextile and the suction applied to it. | Pore size distribution. | Only applicable when sufficient suction can be applied to the geotextile to obtain a meaningful result. Normally applied to geotextiles with pore sizes less than 70 microns. |
| *Image Analyser Technique* (Masounave et al, 1980) : Geotextile is impregnated with transparent resin and a cut and polished cross-section scanned optically using automatic equipment. Porosity and pore size distribution are deduced using probabilistic theory in terms of the observed fibre surface density. | Pore size distribution and porosity. | Only applicable to 'thick' needle-punched nonwovens. Appropriate for pore sizes from 20 to 200 microns. Empirical relationship exists between fibre density and permeability for needle-punched fabrics thicker than 15 mm (Masounave et al, 1980), which enables porosity and pore size distribution to be derived from permeability measurements without direct observation of fibre density. |

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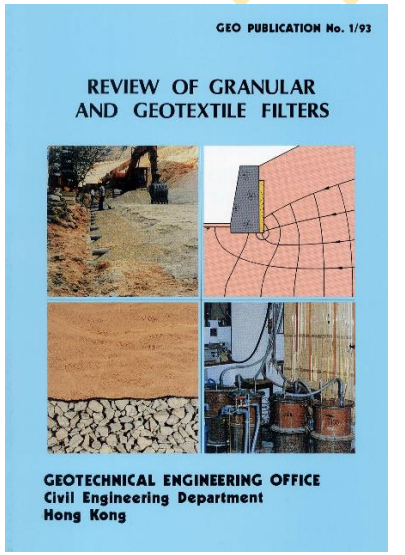


# Do Not Trust Data Sheet from Manufacture, test it yourself



Table 7 - Results of Comparison of Different Test Methods for Determining Geotextile Opening Size

| Geotextile | Construction | $O_{95}$ (1) | $O_{95}$ (2) | $O_{95}$ (3) | $D_w$ (4) | $D_w$ (5) | $O_f$ (6) |
|---|---|---|---|---|---|---|---|
| tFy25 | W, MF | 87 | 72 | 67 | 70 | 69 | 62 |
| tPt48 | W, MF | 195 | 187 | 187 | 125 | 143 | 120 |
| tPt54 | W, MF | 395 | 390 | 385 | 280 | 324 | 320 |
| SC150 | W, ST | 140 | 138 | 140 | 103 | 111 | 100 |
| TP270 | NW, M | 85 | 82 | 74 | 72 | 67 | 72 |
| BD280 | NW, N | 180 | 168 | 163 | 100 | 113 | 113 |
| BD550 | NW, N | 86 | 77 | 105 | 80 | 89 | 72 |
| TS500 | NW, N | 190 | 170 | - | - | 120 (7) | 115 |
| TS600 | NW, N | 185 | 165 | - | - | 110 (7) | 95 |
| TS700 | NW, N | 136 | 138 | 108 | 93 | 90 | 83 |

Legend :

| | | | |
|---|---|---|---|
| W | Woven | NW | Nonwoven |
| MF | Monofilament | M | Heat-bonded (melted) |
| ST | Strip | N | Needle-punched |

Notes on Methods :

(1) By dry sieving using different size fractions of "ballotini" (spherical glass beads).

(2) By dry sieving using different size fractions of sand.

(3) By wet sieving using different size fractions of sand.

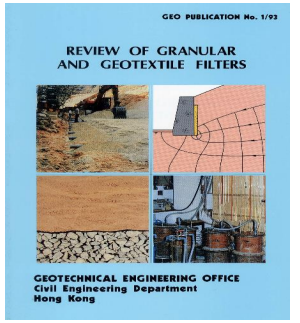
(4) By wet sieving using well-graded sand (based on $D_{95}$ of passing geotextilé, where $D_{95}$ is the 95% size of the sand).

(5) By wet sieving using well-graded sand (Heerten, 1981).

(6) By hydrodynamic sieving using well-graded sand.

(7) Values furnished by the manufacture.

Notes :
(1) This table is based on Faure et al (1986b)
(2) Opening sizes are in microns.



# Permeability Values

**Permeability Values (m/sec) at e=0.5**

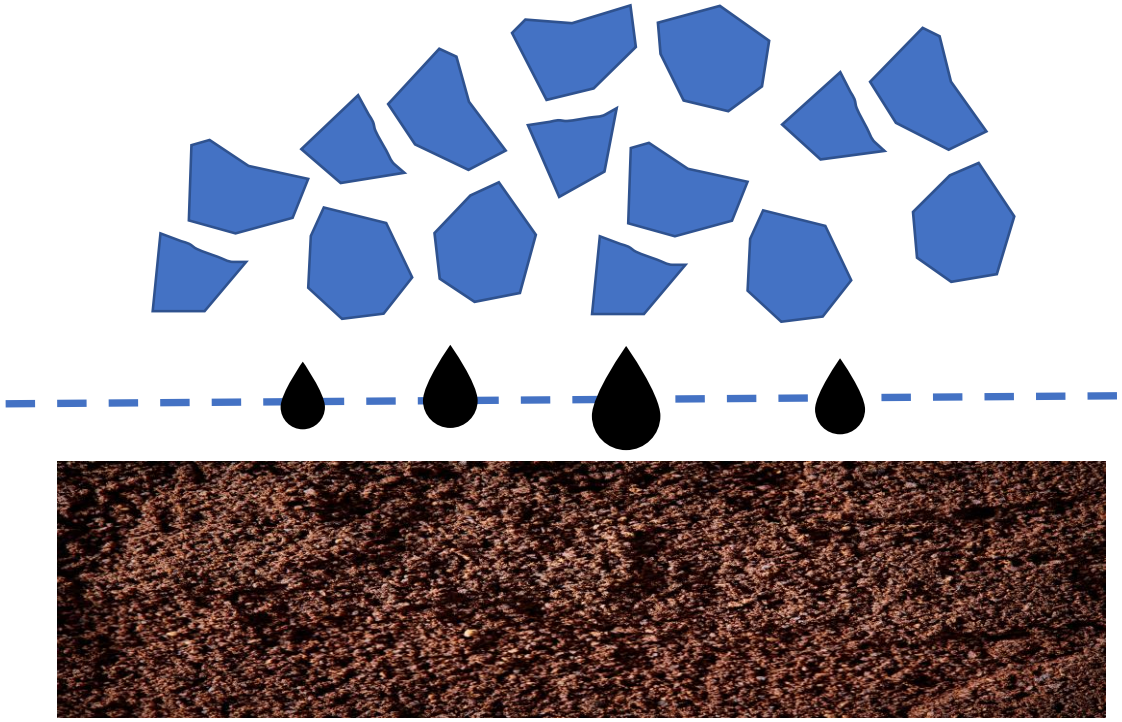
| | |
|---|---|
| Clean sand | ~$10^{-3}$ to $10^{-4}$ |
| Silts and silty sands | ~$10^{-6}$ to $10^{-9}$ |
| Silty clay, low plasticity | ~$10^{-9}$ |
| Clays, medium to high plasticity | ~$10^{-9}$ to $10^{-11}$ |
| Sand-silt-clay mixtures (no clods, low shrinkage) | ~$10^{-9}$ |

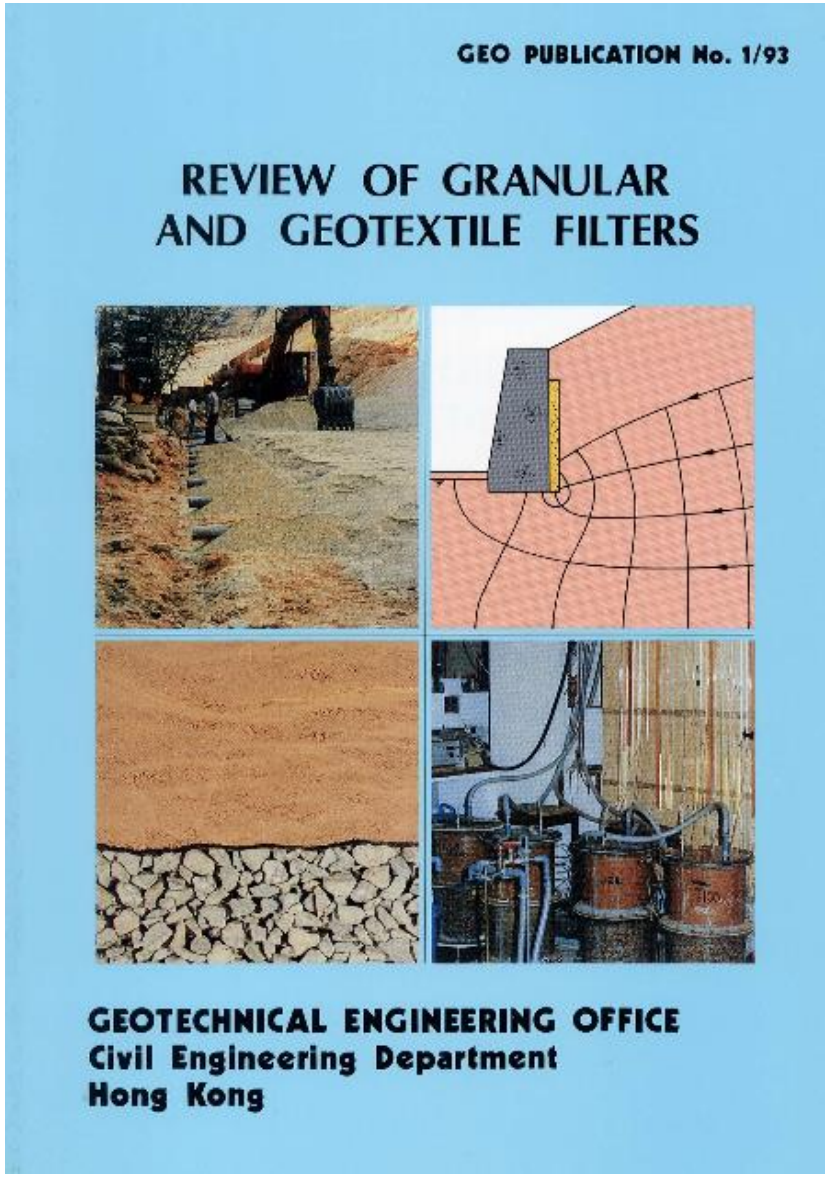
K of commercial bentonite: $10^{-9 \text{ to } -11}$ ; GM: < $10^{-13}$ cm/sec

Explanation of **Soil Permeability**

## 4.3 PERMEABILITY OF BASE SOIL AND FILTER

As a general rule, the filter should be sufficiently more permeable than the base soil it retains. This can generally be achieved using a material coarser than the base soil. In the case where a large quantity of water is expected to flow through the filter, it is essential to determine the permeability of both the filter material and the base soil reasonably accurately to ensure a reliable drainage design.





# ISO 11058

BRITISH STANDARD

BS EN ISO
11058:2010

**Geotextiles and geotextile-related products — Determination of water permeability characteristics normal to the plane, without load (ISO 11058:2010)**

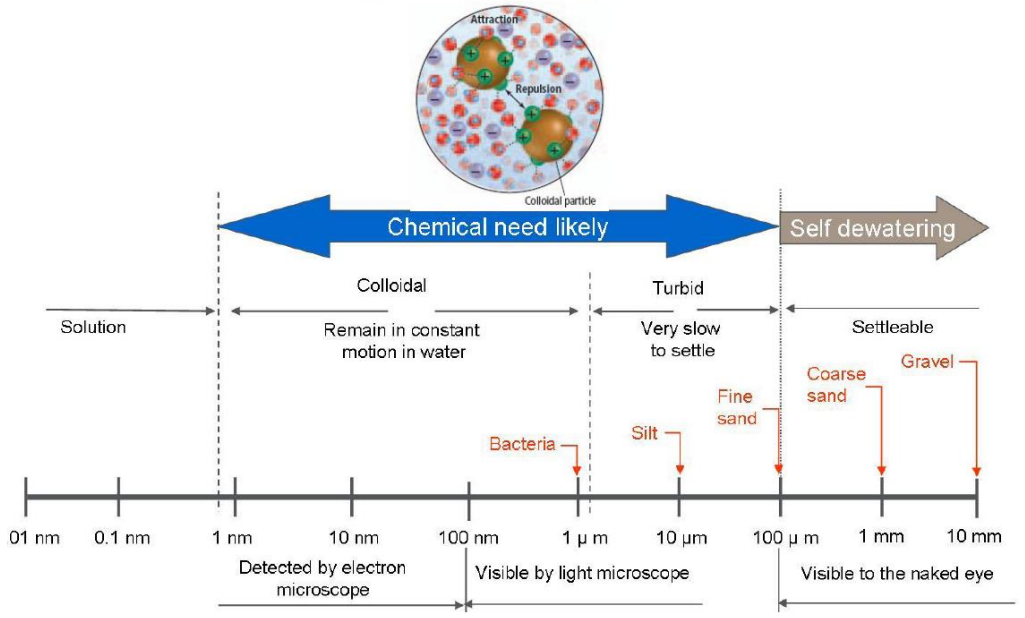
George R. Koerner, Ph.D

Page 15 Standard Page

# Why We Need to Know The Pore Size?

**The need for Dewatering Accelerants** **Engineered Geotube® Solutions**

- Three possible scenarios:
  - No chemical accelerant is required
  - One or more flocculants are applied without prior coagulant application
  - One or more flocculants are applied after coagulant application



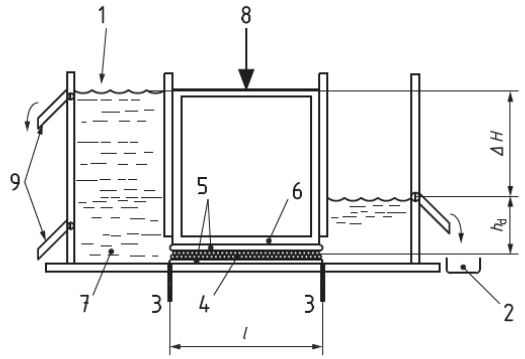

**Micron to Millimeter Conversion Table**

| Micron [µ] | Millimeter [mm] |
|---|---|
| 0.01 µ | 1.0E-5 mm |
| 0.1 µ | 0.0001 mm |
| 1 µ | 0.001 mm |
| 2 µ | 0.002 mm |
| 3 µ | 0.003 mm |
| 5 µ | 0.005 mm |
| 10 µ | 0.01 mm |
| 20 µ | 0.02 mm |
| 50 µ | 0.05 mm |
| 100 µ | 0.1 mm |
| 1000 µ | 1 mm |

flocculants and coagulants

# Horizontal Water Flow– ISO 12958






**Key**

| | | | |
|---|---|---|---|
| 1 | water supply | 7 | water reservoir |
| 2 | water collection | 8 | normal compressive load |
| 3 | upstream water head manometers/piezometers | 9 | overflow weirs at hydraulic gradients 0,1 and 1,0 |
| 4 | specimen | $l$ | effective flow length (≥300 mm) |
| 5 | closed-cell foam rubber (F) or smooth rigid membrane (R) | $\Delta H$ | head loss |
| 6 | loading platen | $h_d$ | downstream water head (≤100 mm) |

**Figure 2 — Typical example of apparatus**


Page 15 Standard Page

# GEO's Filtration Test Setup

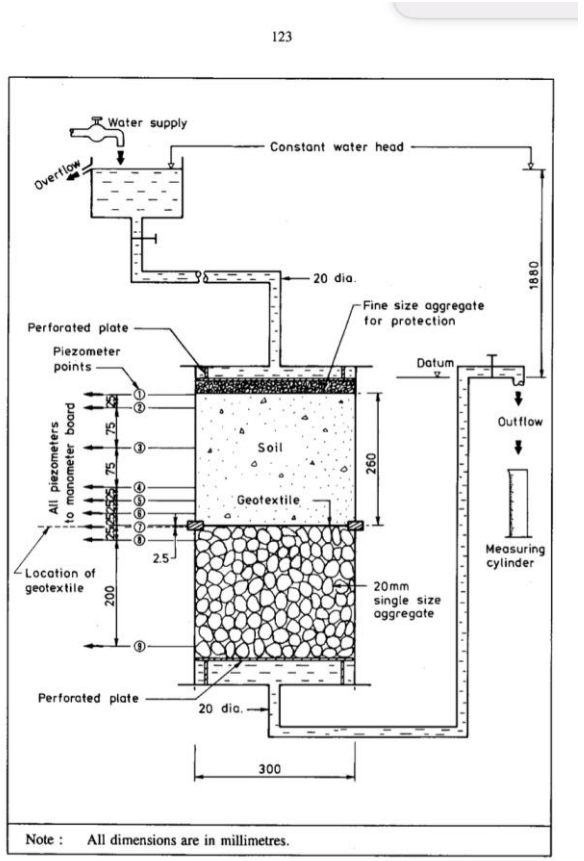
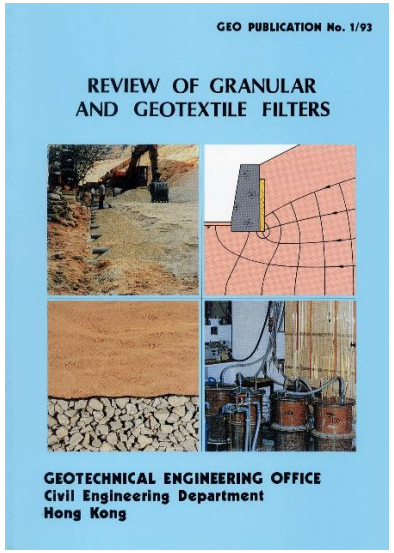



Figure 15 - Schematic Layout of Permeameter for the GEO's Filtration Tests

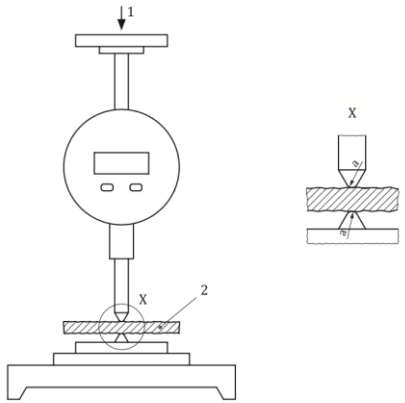


# Thickness 2kpa – ISO 9863



**Annex A**
(normative)

**Details of presser points used for geosynthetics of non-uniform thickness**




**Key**
1 (0,60 ± 0,1) N applied to upper presser point
2 test specimen
[a] Radius of tip (1,0 ± 0,1) mm.

**Figure A.1 — Details of presser points used for geosynthetics of non-uniform thickness**

**5.1.1 Removable presser-foot**, having a plane and smooth surface with an area as defined in Table 1 for testing materials of uniform thickness. For the determination of the overall thickness of materials of polymeric and bituminous geosynthetic barriers of non-uniform thickness, or the thickness of other parts of such materials, refer to Annex A.

**Table 1 — Pressure-foot sizes**

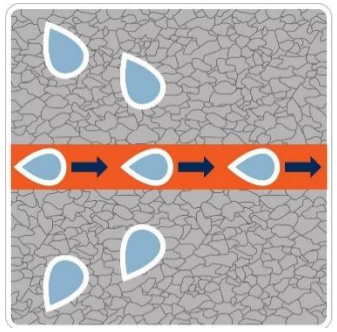
| Type of geosynthetic under test | Presser-foot size |
|---|---|
| Polymeric and bituminous geosynthetic barrier | Circular, (10 ± 0,5) mm diameter |
| Geospacer and drainage geocomposites | square, minimum size of 100 mm × 100 mm size of the load plate and size of the specimen shall satisfy the criteria in ISO 25619-1 |
| Other geosynthetic products | Circular, (25 ± 0,2) $cm^2$ area |

The presser-foot shall be capable of exerting pressures of 2 kPa, 20 kPa and 200 kPa within a tolerance of ±0,5 % normal to the plane of the specimen.

Page 15 Standard Page

# Nonwoven Geotextile

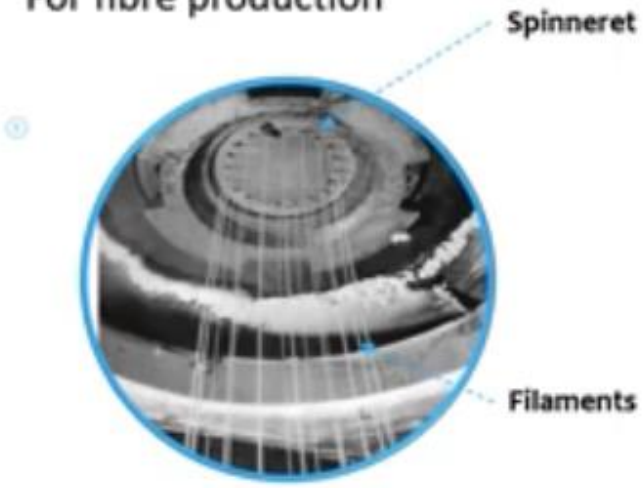
- Geotextile made of directionally or randomly orientated fibers, filaments, or other elements, mechanically and/ or thermally and / or chemically bonded
- 由定向或隨機定向的纖維、長絲或其他元素製成的土工布，機械和/或熱和/或化學粘合

**DRAINAGE (Vertical or Horizontal)**


# Extrusion Process

For fibre production

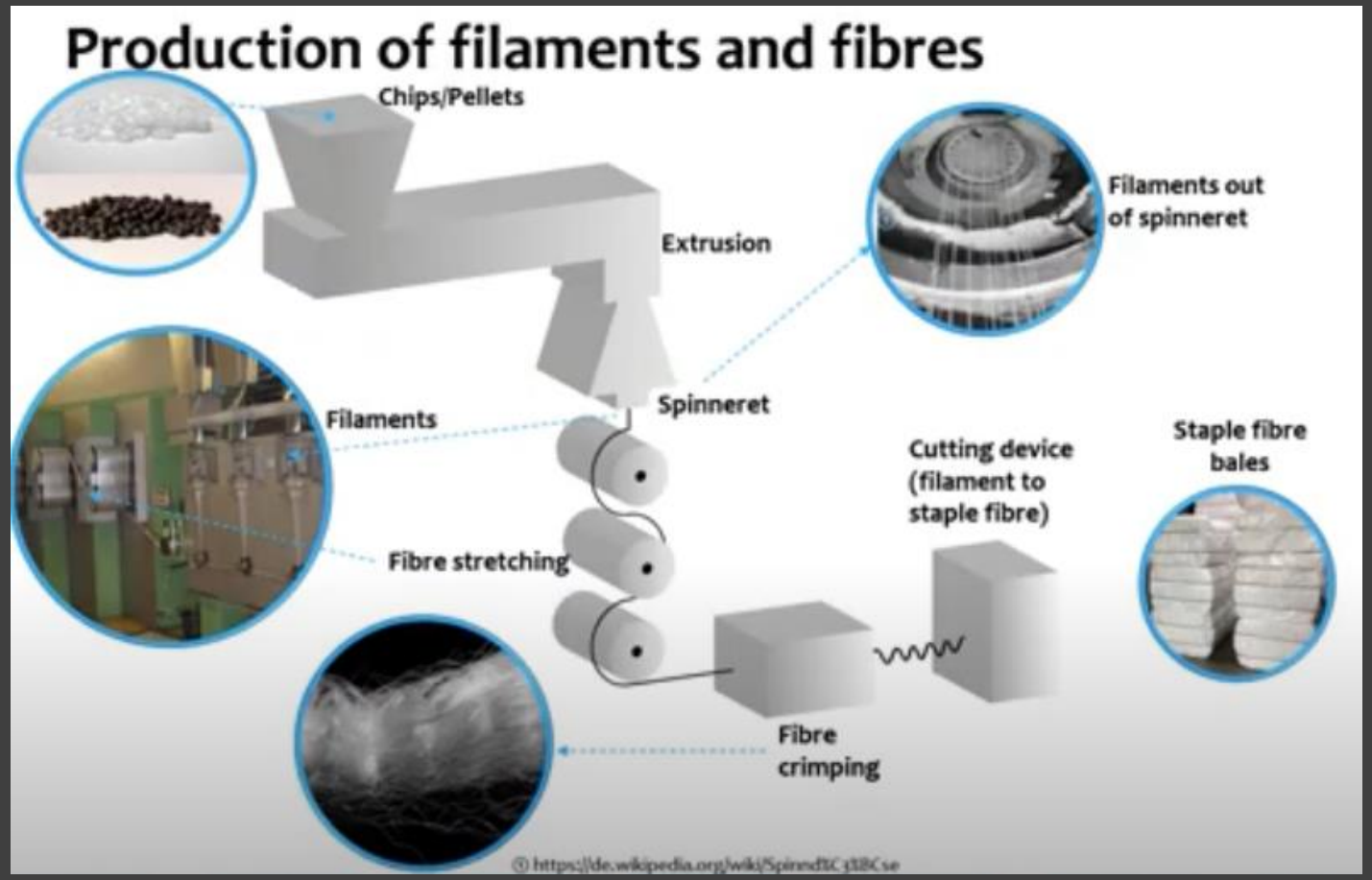



A **spinneret** is a device used to extrude a polymer solution or polymer melt to form filaments.

For sheet production


A **die** is a specialized tool used in manufacturing industries to cut or shape material.

Reference : IGS-international Geosynthetics Society




- Production of Filaments and Fibers
- 長絲纖維生產

Production Demo

Reference : IGS-international Geosynthetics Society

# Type of Fibers and Yarns Typically used for Manufacture of Geotextiles

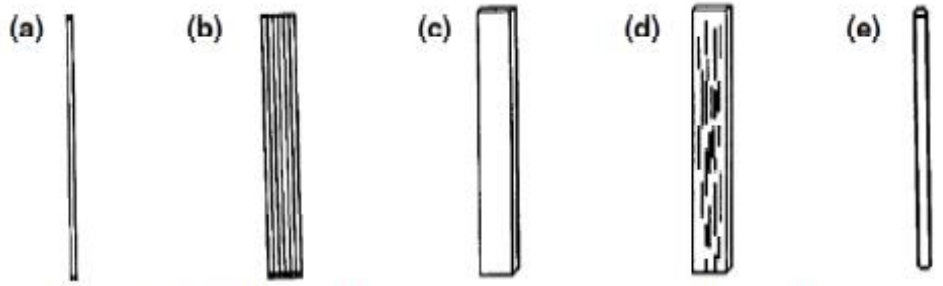
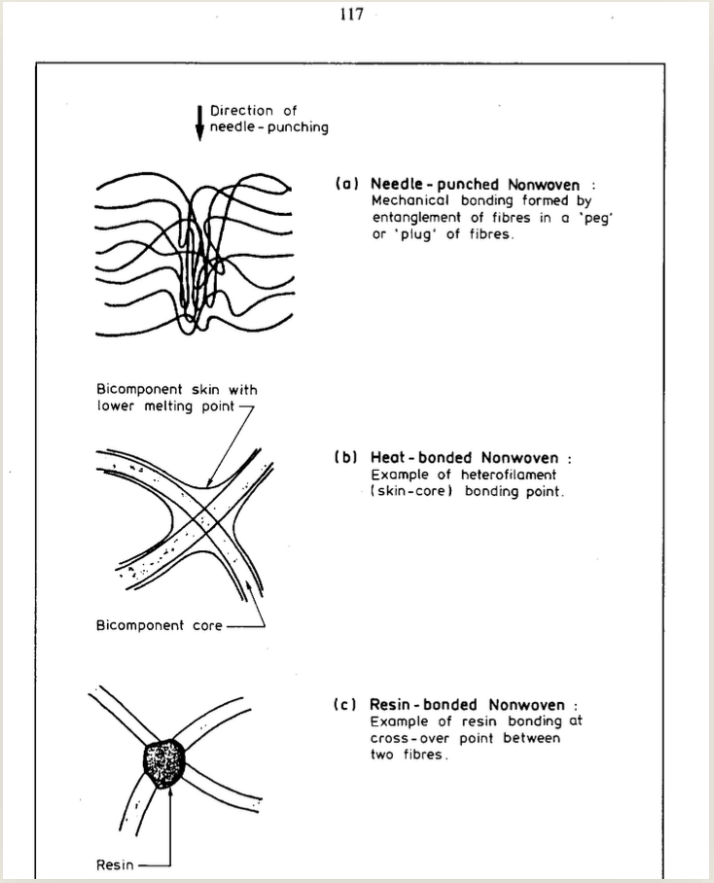



Figure 2. Types of fibers and yarns typically used for manufacture of geotextiles (a) filament yarn (b) multifilament yarn (c) slit tape yarn (d) fibrillated yarn (e) monofilament yarn (adapted from Bhatia and Smith 1996)

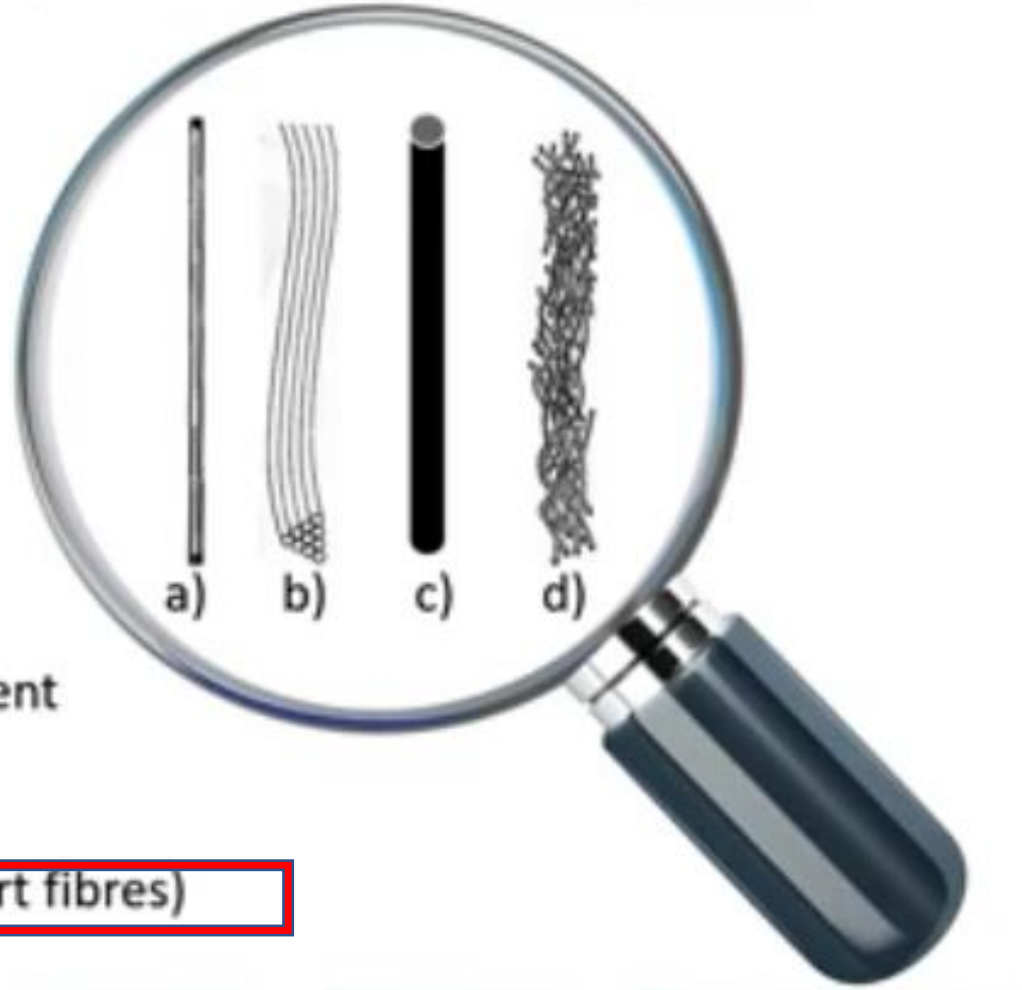

Figure 3. Types of geotextiles (a) needlepunched nonwoven (a) heatbonded nonwoven (c) woven multifilament (d) woven slit tape (e) woven monofilament (adapted from Bhatia and Smith 1996; Aydilek and Edil 2002)




Page 9: Raw Material

# Geosynthetics : Single Components

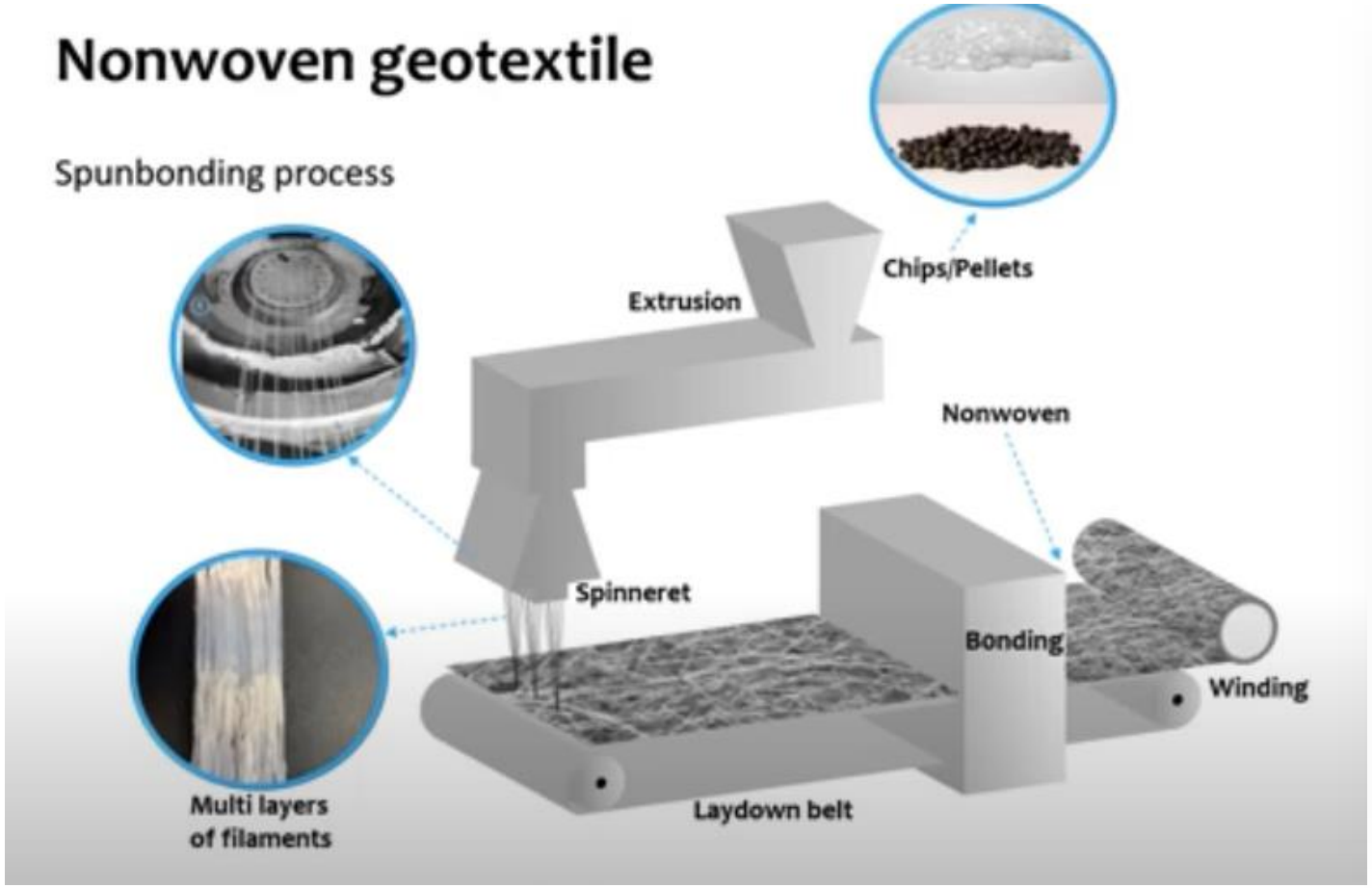
Production: Spunbond (filaments) and staple fibre process

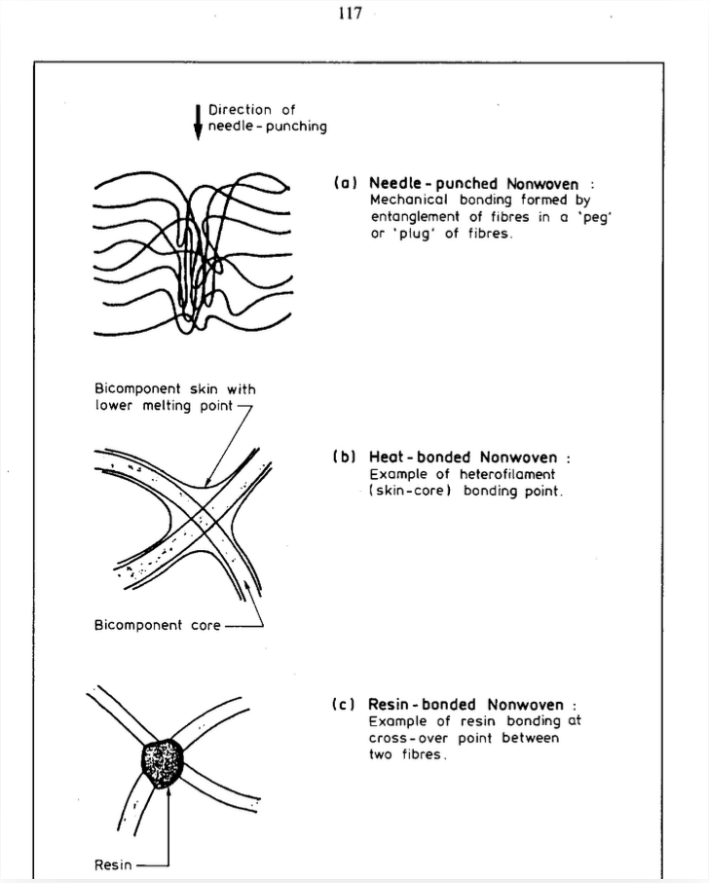



a) Continuous filament
b) Multifilament
c) Monofilament
d) Staple fibres (short fibres)

Reference : IGS-international Geosynthetics Society

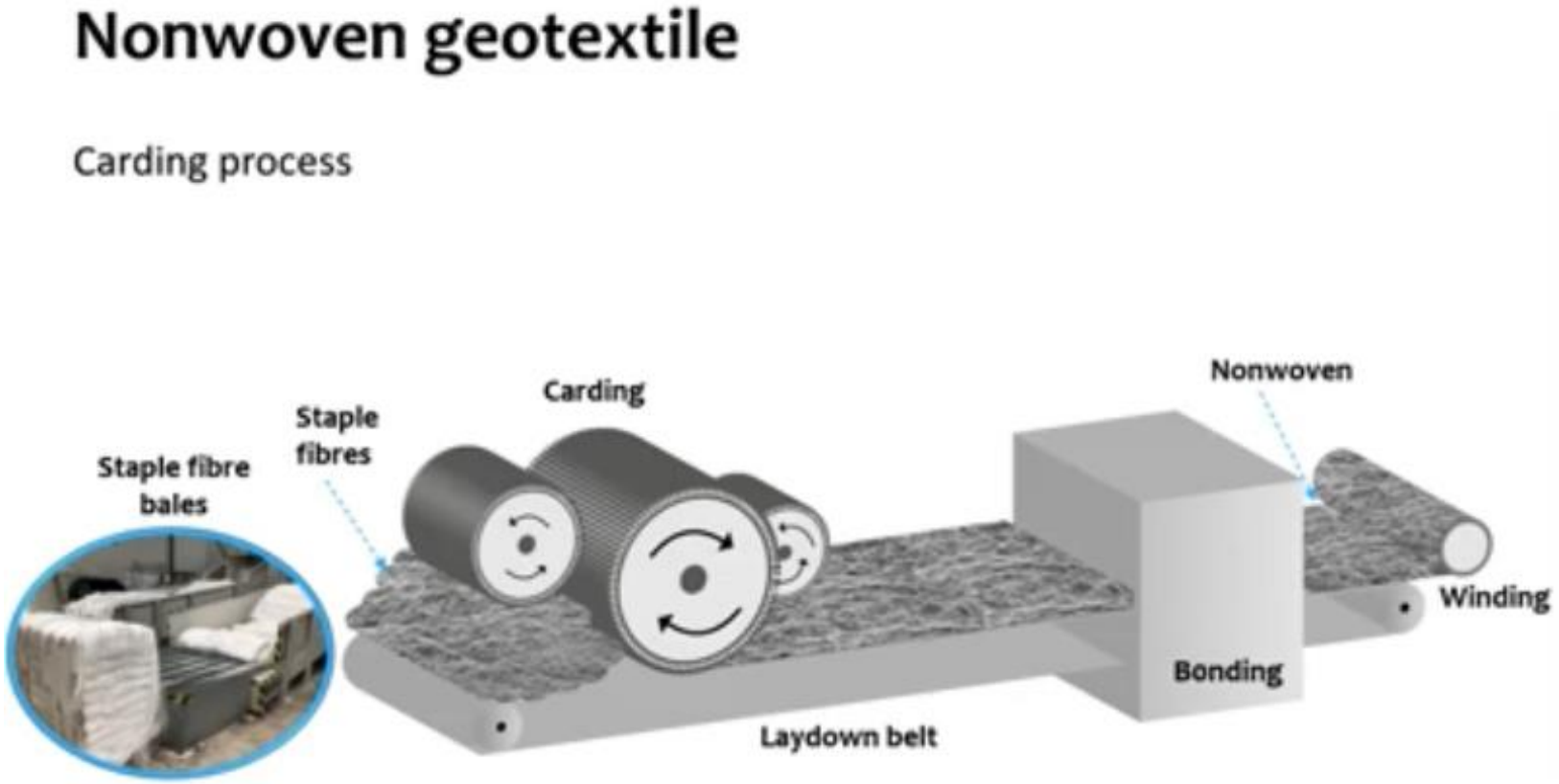
# Nonwoven Geotextile – Spun Bonding Process
# 無紡土工布 - 紡粘工藝

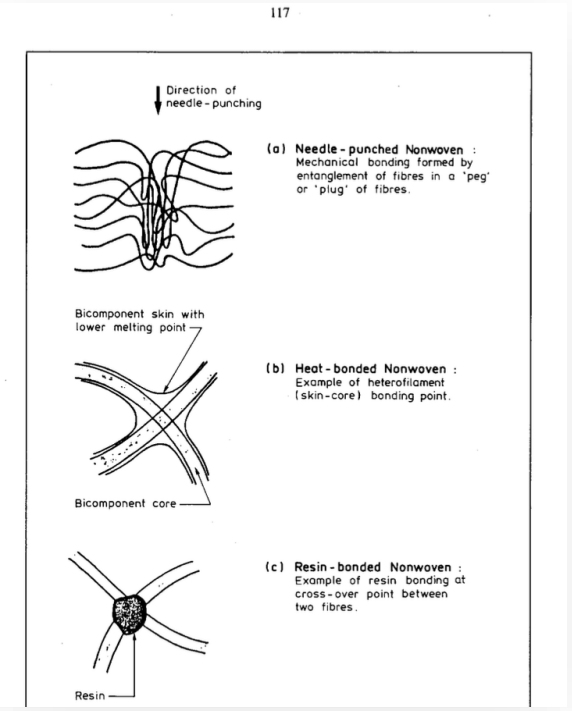



Reference : IGS-international Geosynthetics Society

# Nonwoven Geotextile – Carding Process
# 無紡土工布 - 梳理工藝

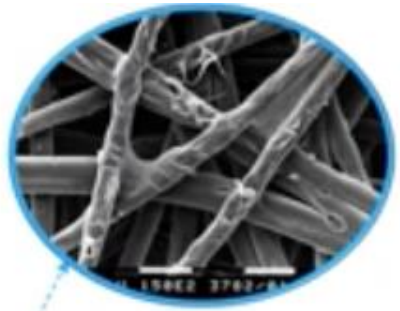


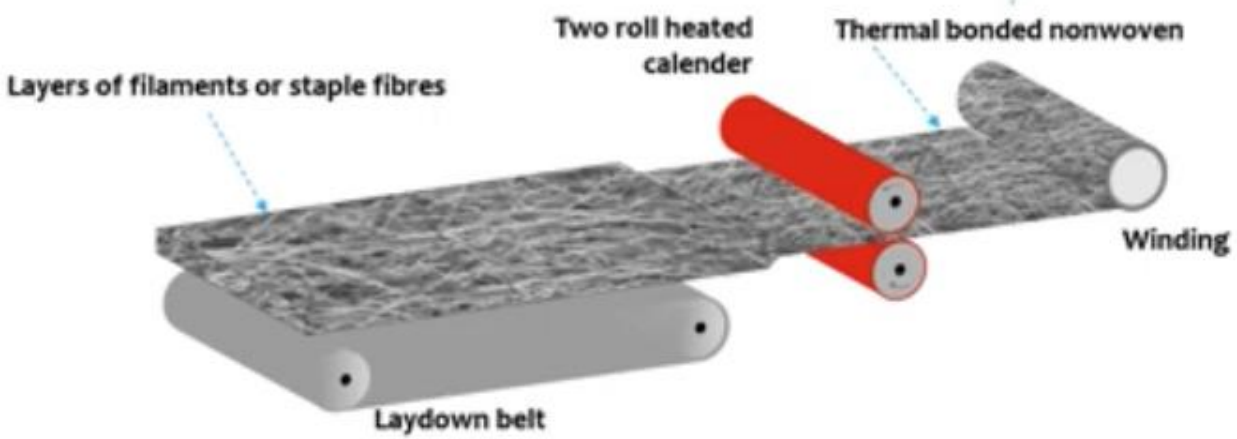




Reference : IGS-international Geosynthetics Society

# Bonding of nonwoven geotextile

Thermal bonding process

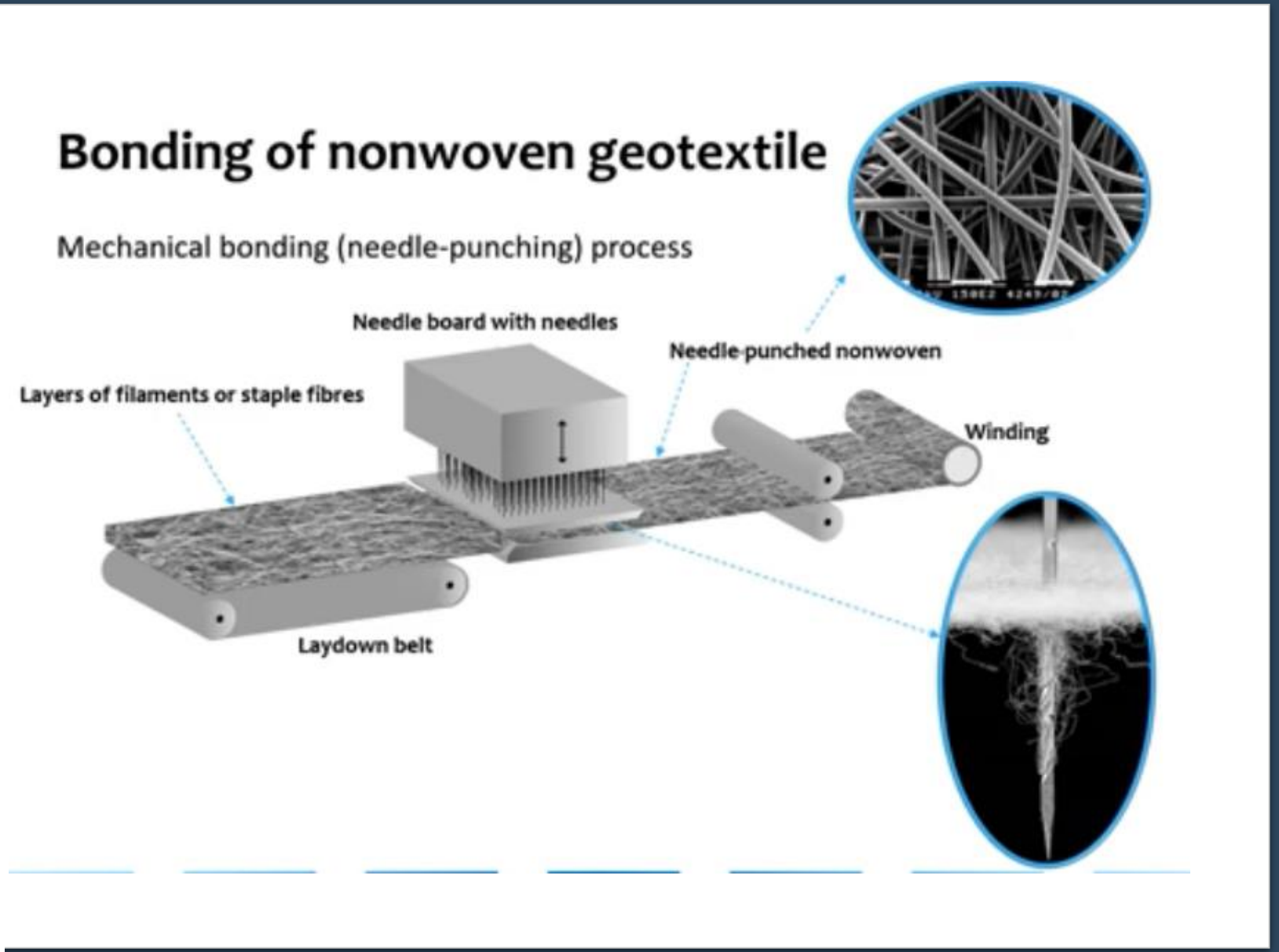


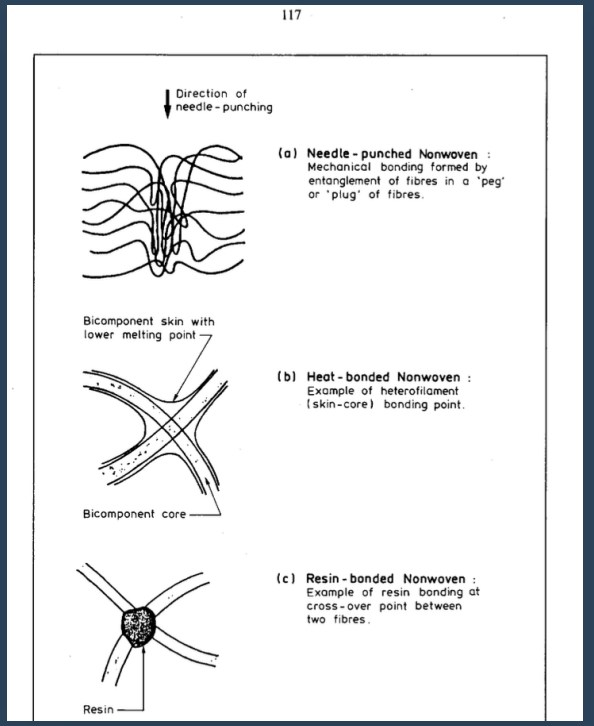



Bonding Process – Thermal Bonding

Reference : IGS-international Geosynthetics Society

# Bonding Process – Mechanical Bonding




Reference : IGS-international Geosynthetics Society

# Typical Physical Properties of Nonwoven Geotextiles

**Properties of Polyfelt® TS Nonwoven Geotextiles**

| Property | Test Standard | Unit | TS 20 | TS 30 | TS 40 | TS 50 | TS 60 | TS 65 | TS 70 | TS 80 |
|---|---|---|---|---|---|---|---|---|---|---|
| Physical characteristics | | | Continuous filament, nonwoven needle punched | | | | | | | |
| Polymer | | | 100% polypropylene, UV stabilised | | | | | | | |
| UV resistance | | | | | | | | | | |
| tensile strength retention | ISO 10319 | | >70% after 3 months of outdoor weathering | | | | | | | |
| puncture strength retention | ISO 12236 | | >70% after 3 months of outdoor weathering | | | | | | | |
| Chemical resistance | | | No influence at pH range 2 -13 | | | | | | | |
| Tensile strength (avg.) | ISO 10319 | kN/m | 9.5 | 11.5 | 13.5 | 15 | 19 | 21.5 | 24 | 28 |
| Tensile elongation (MD/CD) | ISO 10319 | % | 75/35 | 75/35 | 75/35 | 75/35 | 80/35 | 80/40 | 80/40 | 80/40 |
| Performance energy* | Calculated | kN/m | 2.5 | 3.2 | 3.7 | 4.1 | 5.5 | 6.5 | 7.2 | 8.4 |
| CBR puncture strength | ISO 12236 | N | 1500 | 1750 | 2100 | 2350 | 2900 | 3300 | 3850 | 4250 |
| Effective opening size $O_w$ | ISO 12956 | mm | 0.12 | 0.10 | 0.10 | 0.10 | 0.09 | 0.09 | 0.09 | 0.08 |
| Vertical water flow (50mm head) | ISO 11058 | l/m²/s (mm/s) | 115 | 100 | 90 | 85 | 72 | 65 | 55 | 50 |
| Horizontal water flow (20 kPa) | ISO 12958 | l/m.h | 4 | 7 | 9 | 11 | 13 | 14 | 16 | 20 |
| Horizontal water flow (200 kPa) | ISO 12958 | l/m.h | 1.4 | 2.2 | 2.5 | 2.9 | 3.0 | 3.2 | 3.6 | 4.0 |
| Nominal mass | ISO 9864 | g/m² | 125 | 155 | 180 | 200 | 250 | 285 | 325 | 400 |
| Thickness (2 kPa) | ISO 9863 | mm | 1.2 | 1.5 | 1.7 | 1.9 | 2.2 | 2.5 | 2.9 | 3.2 |

Page 9 : Raw Material

# Typical Heavy Duty Nonwoven Geotextiles

## Polyfelt TS Heavy Duty Nonwoven Geotextiles

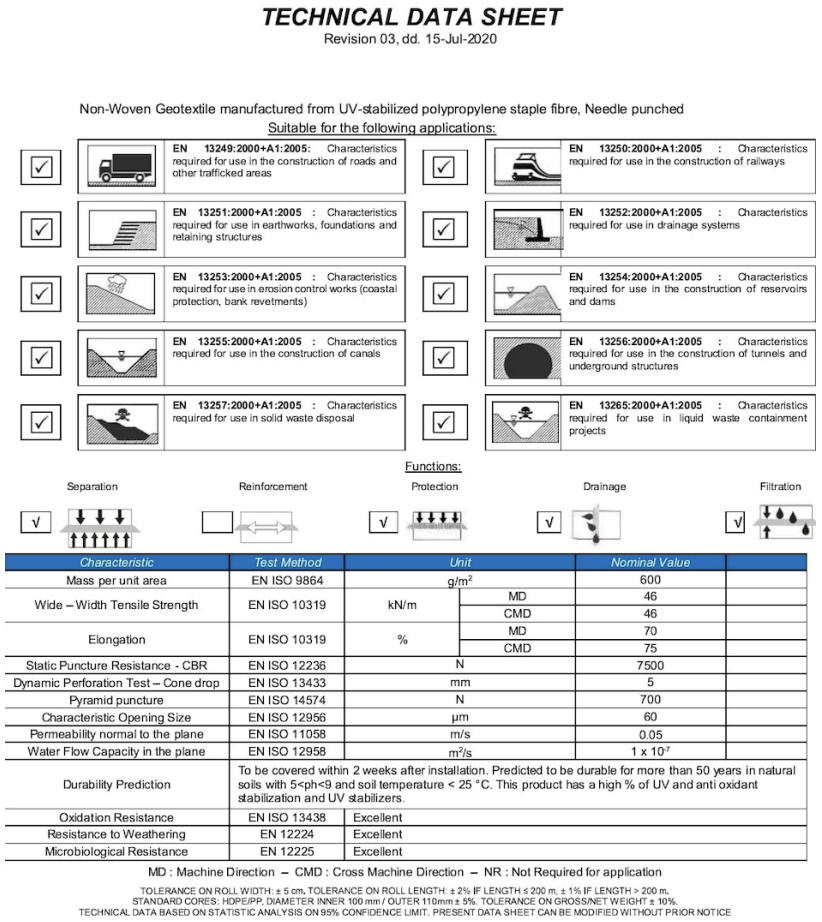
**Properties of Polyfelt TS Heavy Duty Nonwoven Geotextiles**

| Property | | Test Standard | Unit | TS 006 | TS 007 | TS 008 | TS 009 |
|---|---|---|---|---|---|---|---|
| **Physical Characteristics** | | - | - | Continuous filament, nonwoven needle punched | | | |
| **Polymer** | | - | - | 100% polypropylene, UV stabilized | | | |
| **UV Resistance** | | | | | | | |
| - Tensile strength retention | | ISO 10319 | - | > 70% Strength retention after 3 months outdoor weathering | | | |
| - Puncture strength retention | | ISO 12236 | - | > 70% Strength retention after 3 months outdoor weathering | | | |
| **Chemical Resistance** | | - | - | No influence at pH range 2 – 13 | | | |
| Tensile strength | (ave) | ISO 10319 | kN/m | 34 | 40 | 42 | 45 |
| Tensile elongation | (MD/CD) | ISO 10319 | % | 80/50 | 80/50 | 80/50 | 80/50 |
| Performance energy * | | Calculated | kN/m | 11.00 | 12.00 | 13.50 | 14.50 |
| CBR puncture strength | | ISO 12236 | N | 5400 | 6200 | 7200 | 7800 |
| Dynamic drop cone puncture | (diam) | ISO 13433 | mm | 11 | 10 | 9 | 8 |
| Effective opening size | ($O_{90}$) | ISO 12956 | mm | 0.08 | 0.08 | 0.07 | 0.07 |
| Vertical water flow 50mm head | | ISO 11058 | l/m²/s (mm/s) | 42 | 36 | 31 | 27 |
| Horizontal water flow | 20 kPa | ISO 12958 | l/m.h | 21 | 24 | 28 | 33 |
| in plane | 200 kPa | ISO 12958 | l/m.h | 4.00 | 5.00 | 6.00 | 7.00 |
| Nominal mass | | ISO 9864 | g/m² | 500 | 600 | 700 | 800 |
| Thickness | 2 kPa | ISO 9863 | mm | 4.00 | 4.50 | 5.30 | 6.00 |
| Grab strength | (MD/CD) | ASTM D 4632 | N | 2350/2150 | 2900/2900 | 3300/3100 | 4000/3700 |
| Grab elongation | (MD/CD) | ASTM D 4632 | % | 80/50 | 80/50 | 80/50 | 80/50 |
| Apparent opening size | ($O_{90}$) | ASTM D 4751 | mm | < 0.075 | < 0.075 | < 0.075 | < 0.075 |
| Permittivity | | ASTM D 4491 | s⁻¹ | 0.95 | 0.85 | 0.70 | 0.60 |
| **Form of supply** | | | | | | | |
| Width | | | m | 4 | 4 | 4 | 4 |
| Length | | | m | 75 | 65 | 55 | 45 |
| Area | | | m² | 300 | 260 | 220 | 180 |
| Weight of roll | | | kg | 160 | 166 | 164 | 154 |

Page 9 : Raw Material

# Staple Fiber (Short Fiber)

- Normally, Staple fibre non-woven work well in Garden drainage, but not on Civil Engineering Project like Landfill or Land Reclamation.
- •One of the reasons is that we cannot stitch short fibre non-woven as well as long filament.
- •We also need to be careful about the wording used in some technical data sheets. For example, on our righthand side, the data sheet said it is a staple fibre, needle punched. This is not technically correct because short fibre cannot be needle punched, it can only press or heat bonded or chemically bound.



**TECHNICAL DATA SHEET**
Revision 03, dd. 15-Jul-2020

Non-Woven Geotextile manufactured from UV-stabilized polypropylene staple fibre, Needle punched

Suitable for the following applications:

- ☑ **EN 13249:2000+A1:2005:** Characteristics required for use in the construction of roads and other trafficked areas
- ☑ **EN 13250:2000+A1:2005 :** Characteristics required for use in the construction of railways
- ☑ **EN 13251:2000+A1:2005 :** Characteristics required for use in earthworks, foundations and retaining structures
- ☑ **EN 13252:2000+A1:2005 :** Characteristics required for use in drainage systems
- ☑ **EN 13253:2000+A1:2005 :** Characteristics required for use in erosion control works (coastal protection, bank revetments)
- ☑ **EN 13254:2000+A1:2005 :** Characteristics required for use in the construction of reservoirs and dams
- ☑ **EN 13255:2000+A1:2005 :** Characteristics required for use in the construction of canals
- ☑ **EN 13256:2000+A1:2005 :** Characteristics required for use in the construction of tunnels and underground structures
- ☑ **EN 13257:2000+A1:2005 :** Characteristics required for use in solid waste disposal
- ☑ **EN 13265:2000+A1:2005 :** Characteristics required for use in liquid waste containment projects

Functions:

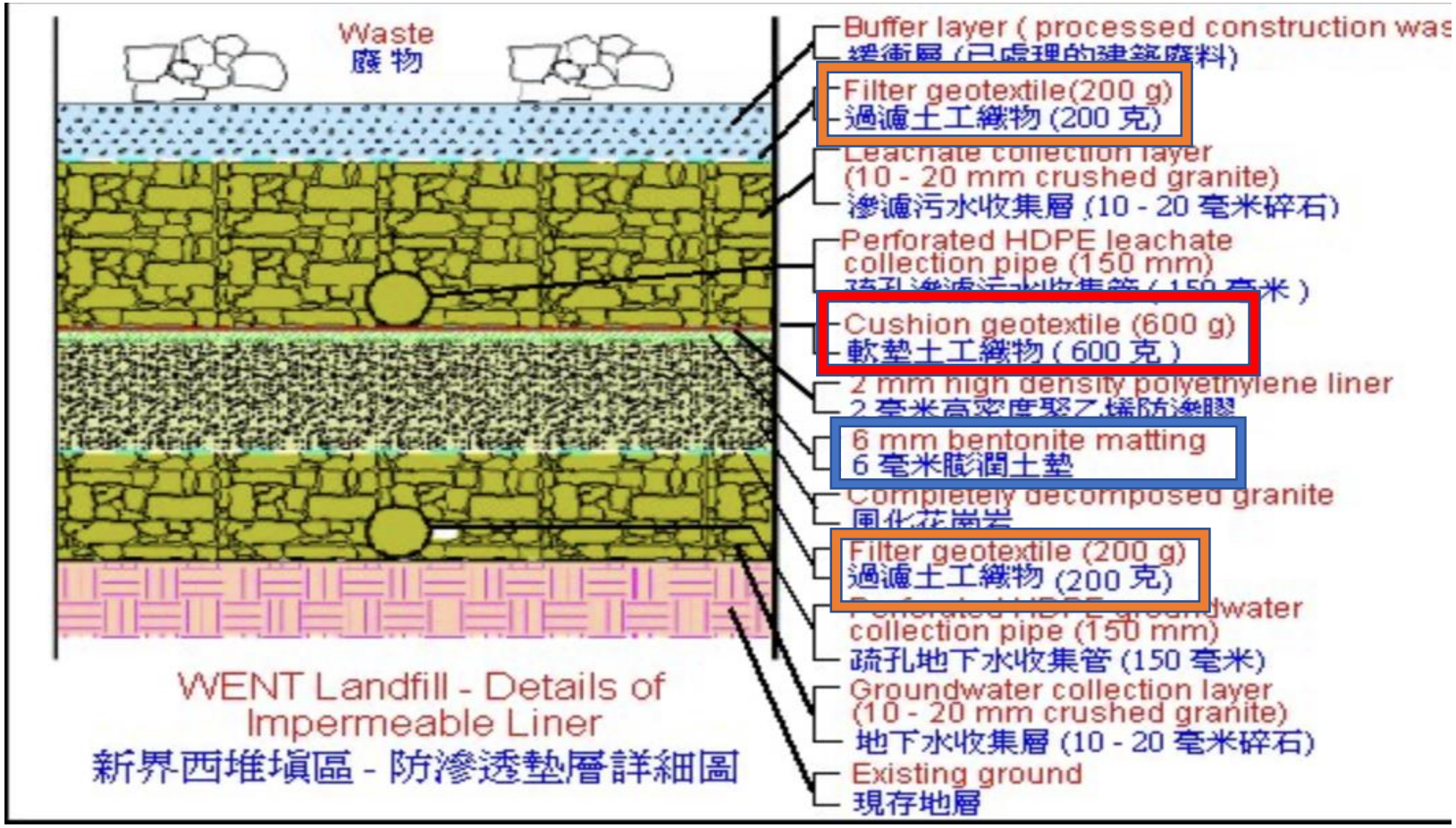
| Separation | Reinforcement | Protection | Drainage | Filtration |
|---|---|---|---|---|
| √ | ☐ | √ | √ | √ |

| Characteristic | Test Method | Unit | | Nominal Value | |
|---|---|---|---|---|---|
| Mass per unit area | EN ISO 9864 | g/m² | | 600 | |
| Wide – Width Tensile Strength | EN ISO 10319 | kN/m | MD | 46 | |
| | | | CMD | 46 | |
| Elongation | EN ISO 10319 | % | MD | 70 | |
| | | | CMD | 75 | |
| Static Puncture Resistance - CBR | EN ISO 12236 | N | | 7500 | |
| Dynamic Perforation Test – Cone drop | EN ISO 13433 | mm | | 5 | |
| Pyramid puncture | EN ISO 14574 | N | | 700 | |
| Characteristic Opening Size | EN ISO 12956 | µm | | 60 | |
| Permeability normal to the plane | EN ISO 11058 | m/s | | 0.05 | |
| Water Flow Capacity in the plane | EN ISO 12958 | m²/s | | 1 x $10^{-7}$ | |
| Durability Prediction | To be covered within 2 weeks after installation. Predicted to be durable for more than 50 years in natural soils with 5<ph<9 and soil temperature < 25 °C. This product has a high % of UV and anti oxidant stabilization and UV stabilizers. | | | | |
| Oxidation Resistance | EN ISO 13438 | Excellent | | | |
| Resistance to Weathering | EN 12224 | Excellent | | | |
| Microbiological Resistance | EN 12225 | Excellent | | | |

MD : Machine Direction – CMD : Cross Machine Direction – NR : Not Required for application

TOLERANCE ON ROLL WIDTH: ± 5 cm. TOLERANCE ON ROLL LENGTH: ± 2% IF LENGTH ≤ 200 m, ± 1% IF LENGTH > 200 m.
STANDARD CORES: HDPE/PP, DIAMETER INNER 100 mm / OUTER 110mm ± 5%. TOLERANCE ON GROSS/NET WEIGHT ± 10%.
TECHNICAL DATA BASED ON STATISTIC ANALYSIS ON 95% CONFIDENCE LIMIT. PRESENT DATA SHEET CAN BE MODIFIED WITHOUT PRIOR NOTICE

# Safety Selection of Geotextile – How You Ask For a Submission and Quotation From Supplier?



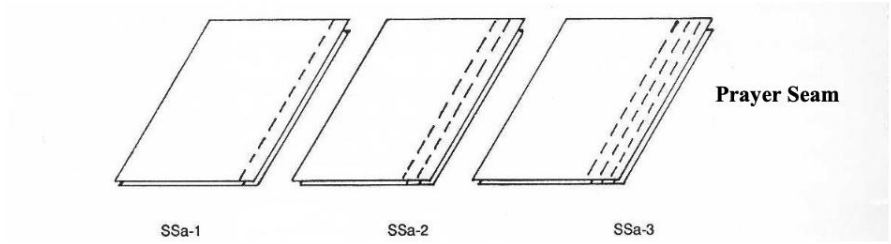

Ref: HK WENT Landfill Liner System

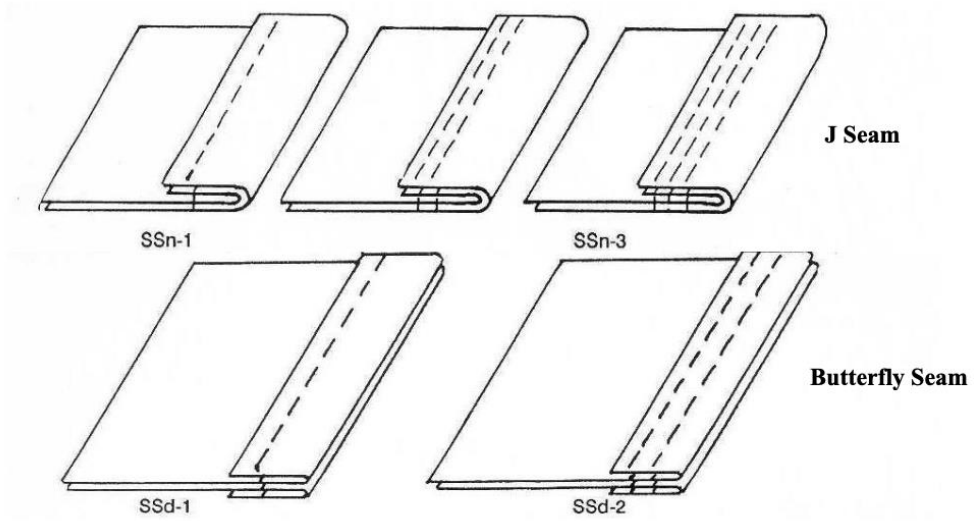
# Ask for these Parameters, at least!

1. Physical Characteristic – Continuous Filament, UV Stabilized, 100% Needle Punched
2. UV Resistance >70% After 3 Months Outdoor Weathering
3. Chemical Resistance – No Influence At Ph 2-13
4. Tensile Strength (MD / CD) Machine Direction And Cross Dimension
5. Tensile Elongation
6. CBR Puncture Strength
7. Grab Strength
8. Thickness
9. Apparent Opening Size
10. Do Not Specify Non-woven Base On The Nominal Mass Only

# Different Type of Seam

Seam Type: Three types of seams are commonly used: 1) "flat" or "prayer" seam, 2) "J" seam, and 3) "butterfly" seam. The following diagrams indicate the three seam types.




How Strong a Seam can be?

The "prayer" seam is the easiest to produce and is commonly used for required seam strengths of 17.5 kN/m ( 100 lb/in) or less. The "J" and "butterfly" seams are more difficult to produce and are commonly used to develop higher seam strengths.

# Stitching Example (Chain Stitching)

**Sewing thread:** Polyester 9000D

**Stitch type:** Chain stitch

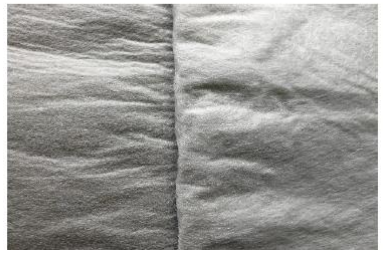
**Stitch step:** 7mm

**Seam photos:**

1) Front view

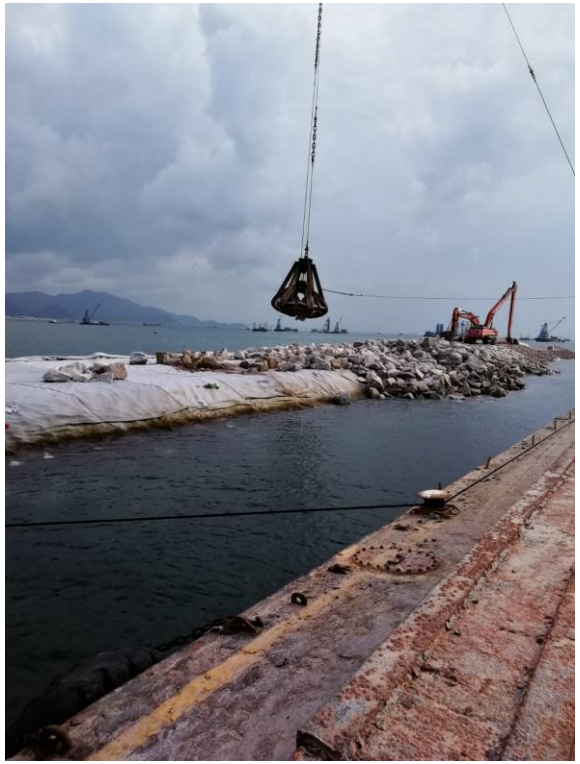
2) Top view

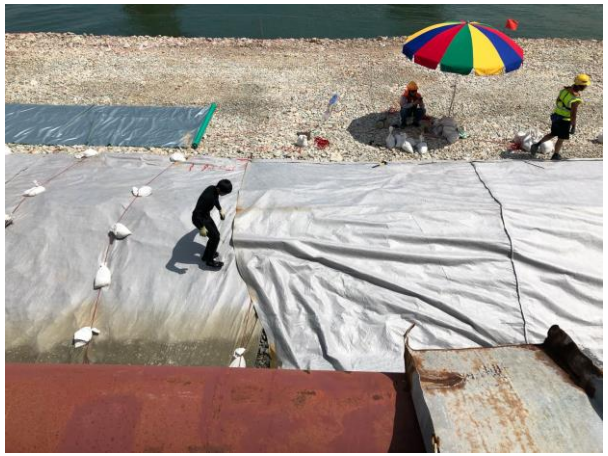
3) Bottom view



# 斜波海堤石舉

Non – Woven Job Reference



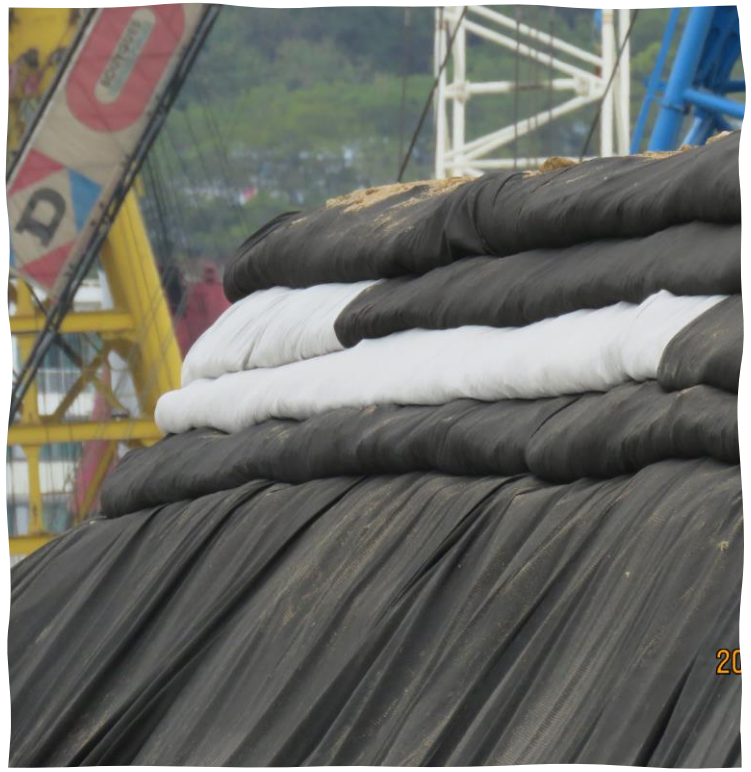


# 斜波海堤石舉

Non – Woven Job Reference

# TMCLK-土工布臨時護土牆 - 2015

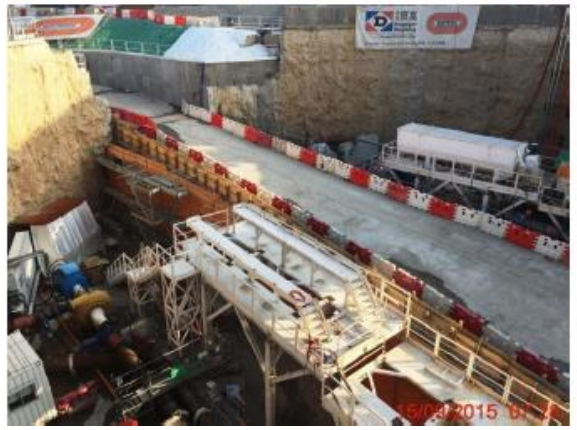




## Tuen Mun - Chek Lap Kok Link

Case Study

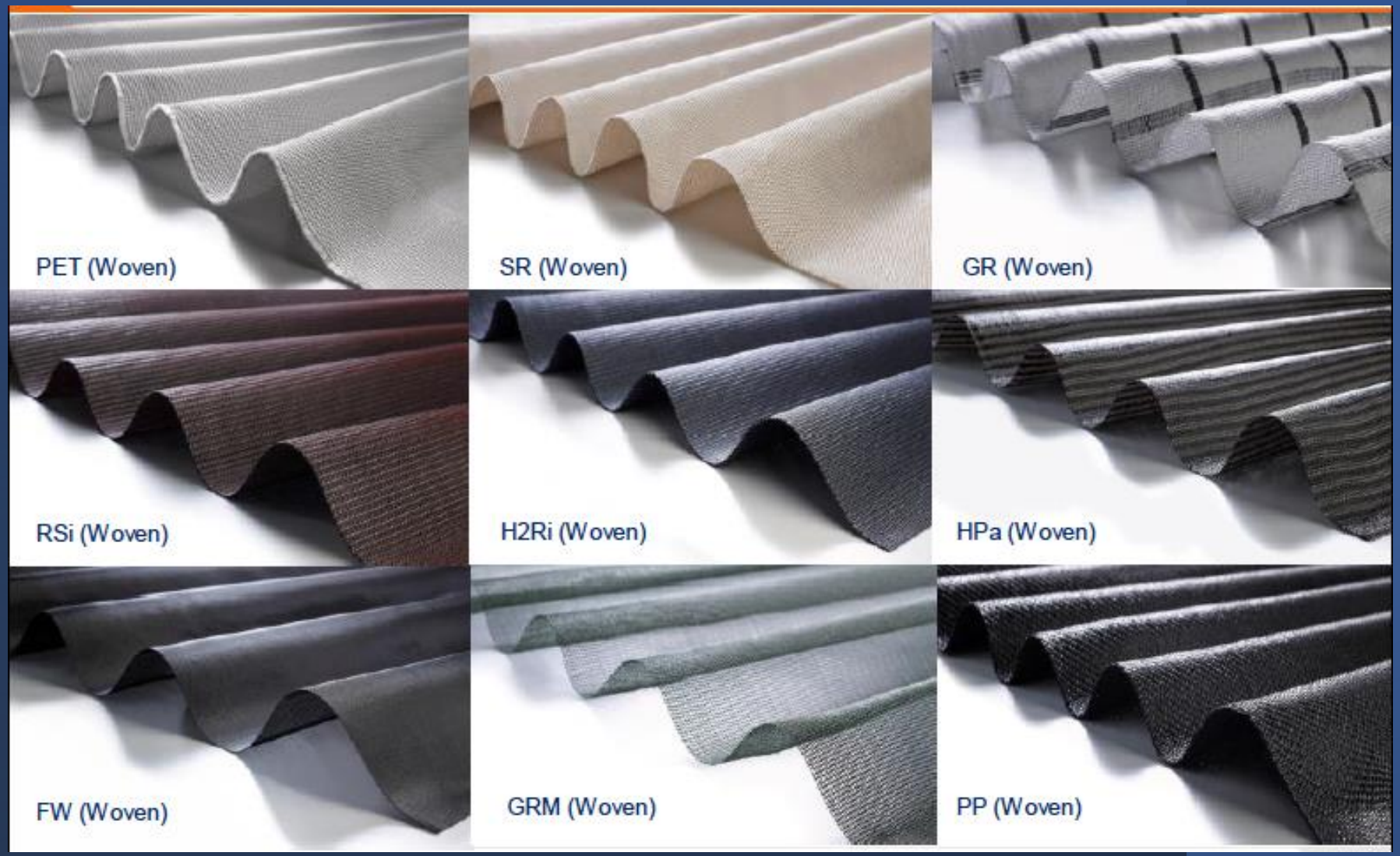
| | |
|---|---|
| Reinforcement: | 11,000 $m^2$ Mirafi® PET200/50 @ 0.5 m vertical spacing |
| Backfill: | General cohesive granular fill ($\gamma$ = 19 kN/$m^3$, $\phi'$ = 30°, $C'$ = 0) |
| Facing: | Bent welded steel wire mesh (1h:10v) |

# Protector on Geo Membrane (non-Woven Geotextile)- Stitching the Non-Woven Geotextile

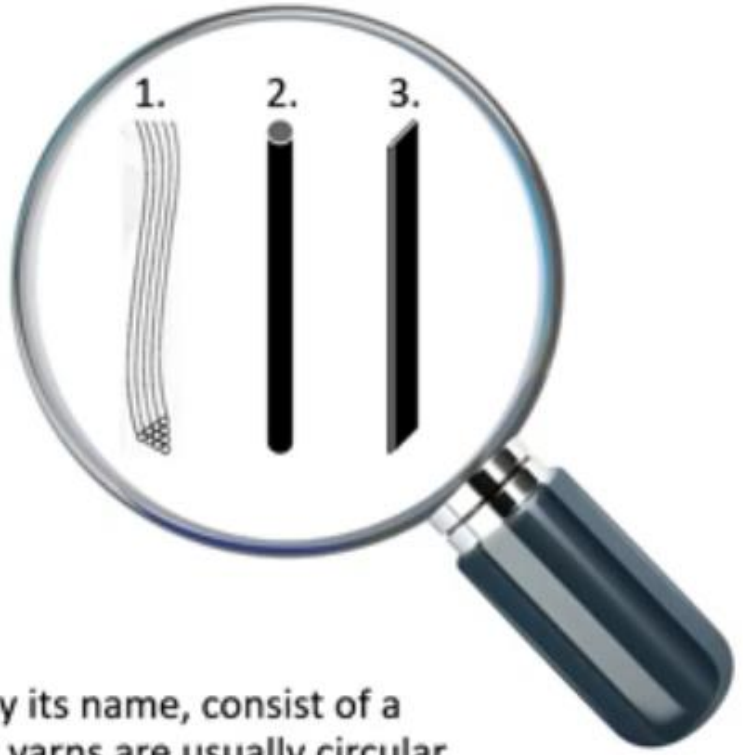
# Woven Geotextile Type

- Woven Fabric, Geo Textile
- Common geotextile type weaving like usual clothing, two parallel threads or yarns


PET (Woven)
SR (Woven)
GR (Woven)
RSi (Woven)
H2Ri (Woven)
HPa (Woven)
FW (Woven)
GRM (Woven)
PP (Woven)

# Woven geotextiles

Tapes, Yarns, Filaments




1. A **multifilament yarn** is composed of a bundle of very thin, infinitely long threads. The threads are generally referred to as filaments.

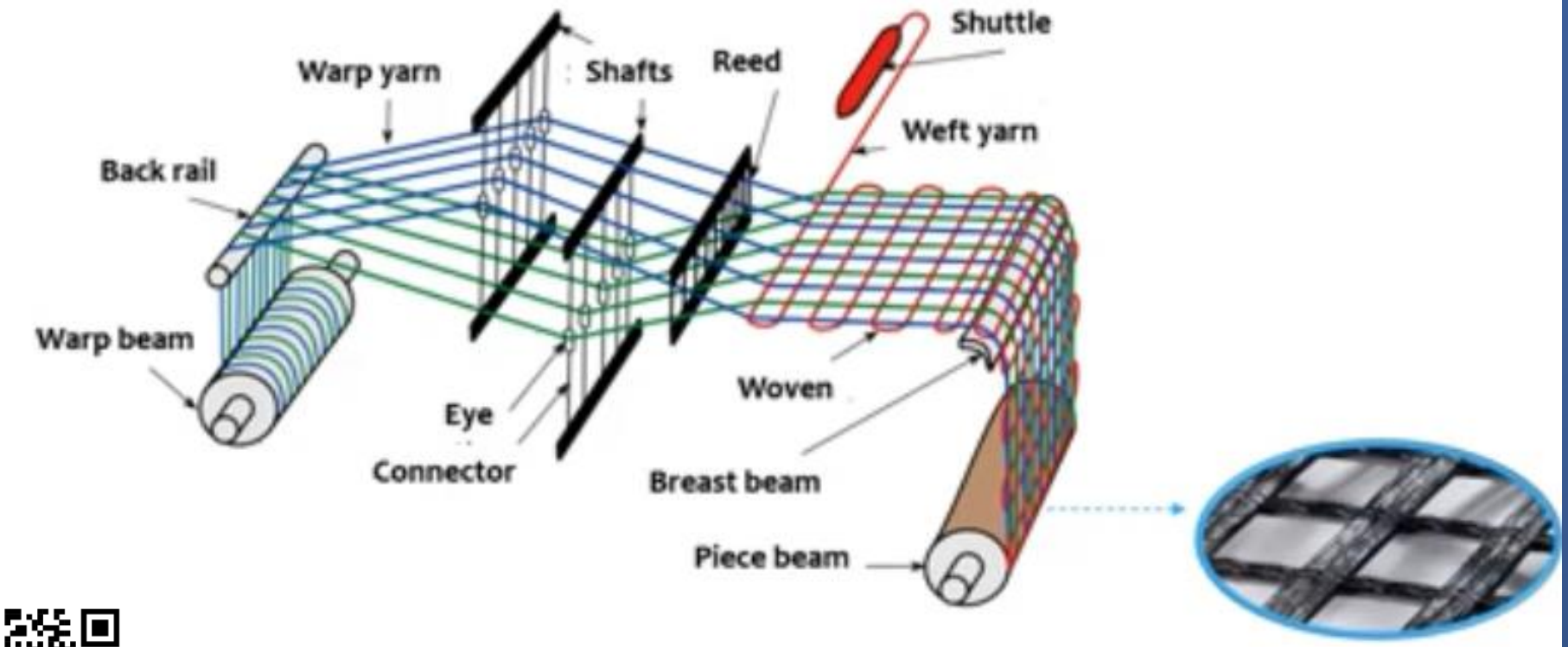
2. **Monofilament yarn**, as evident by its name, consist of a single solid filament. Monofilament yarns are usually circular and solid in cross section, typically 30 µm to 3 mm.

3. **Slit film tapes** are manufactured by cutting sheets of an impermeable film into narrow strips.

Reference : IGS-international Geosynthetics Society

# Woven/knitted geogrid

Interlooping or interlacing




Reference : IGS-international Geosynthetics Society

# Woven Pattern (Kitted)

116

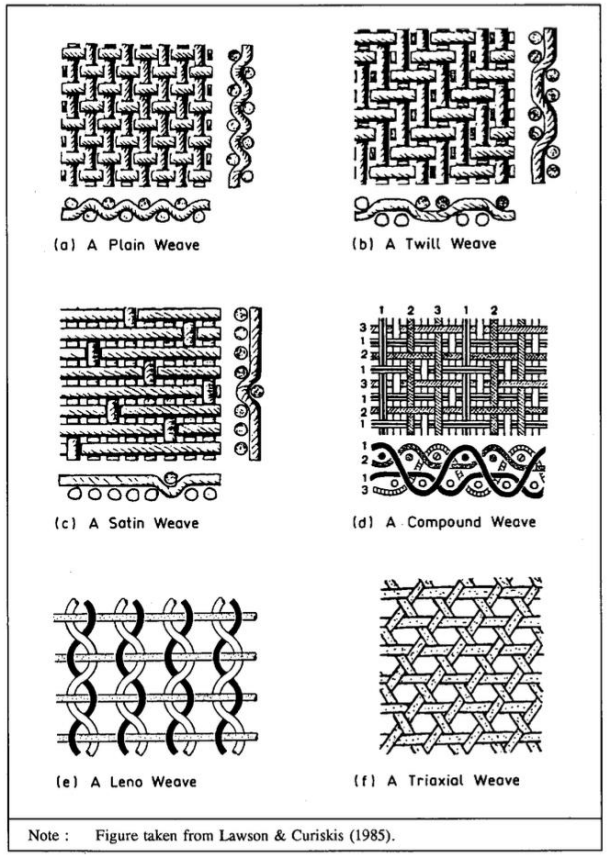
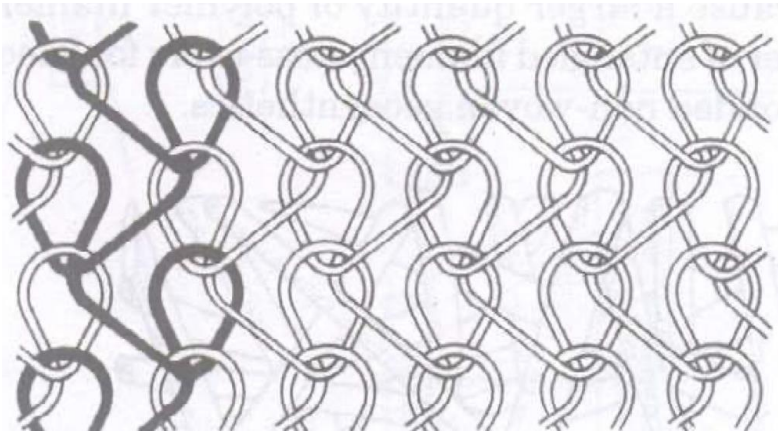
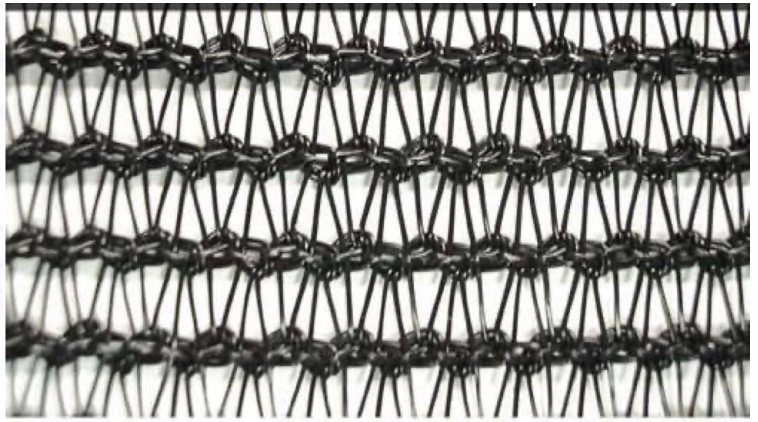


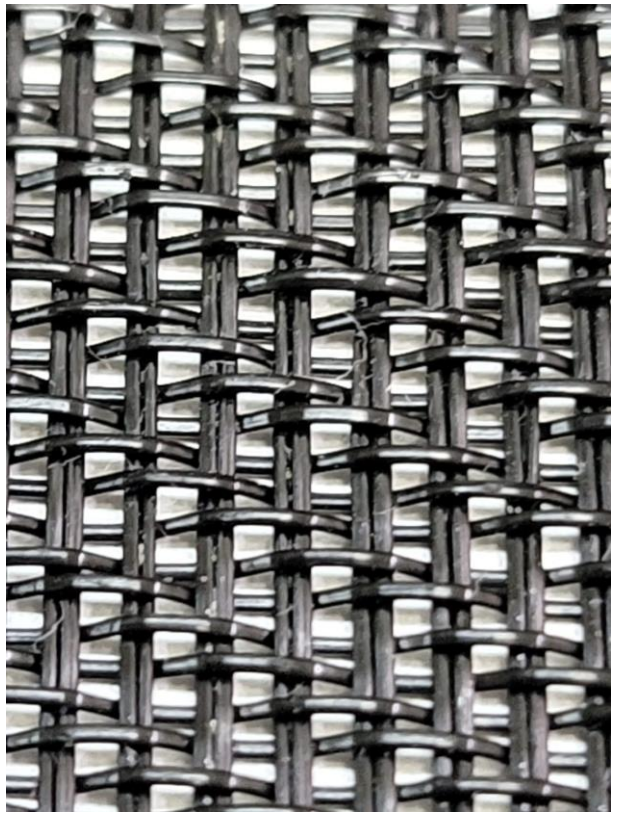

Figure 8 - Schematic Diagrams of Some Woven Fabric Construction



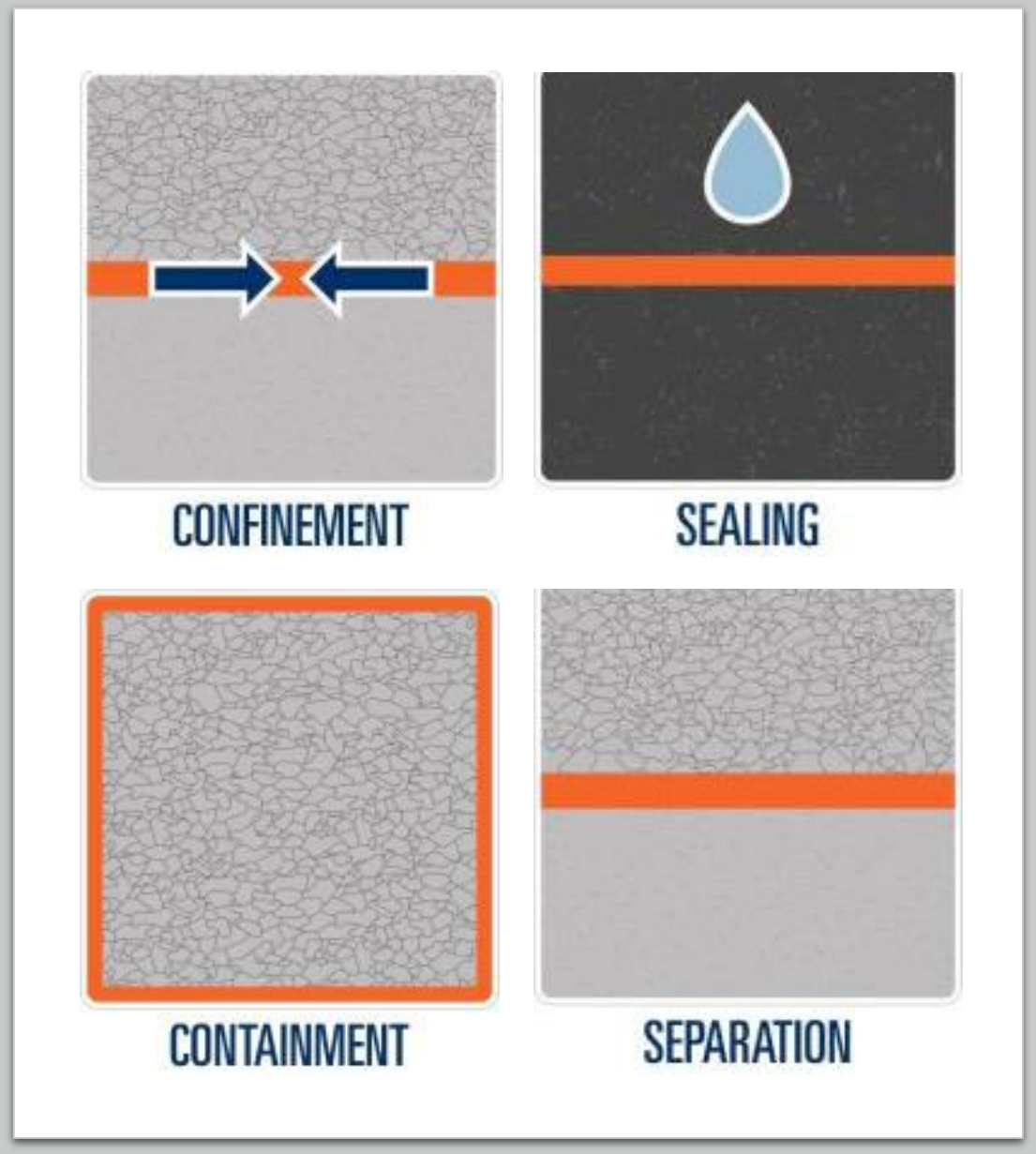


GT750- Multifilament yarn

GT330- Monofilament yarn



GT550- Multifilament / Monofilament yarn




# Woven Geotextiles Function

- Geotextile produced by interlacing, usually at right angles, two or more sets of yarns, filaments, tapes, or other elements
- 機織土工布，通常以直角交織兩組或多組紗線、長絲、帶或其他元素製成

# Typical Technical Data For Woven PET Geotextile – One Way

TENCATE Mirafi®

## TECHNICIAL DATA

Sample

| | | | |
|---|---|---|---|
| Date of issue: | 11 May, 2021 | | |
| Project title: | Contract 3802 Apm and Bhs Tunnels and Related Works (Contract 3802) | | |
| Product name: | **Mirafi® PET1000-100** | | |
| Manufacturer: | TenCate Industrials Zhuhai Co., Ltd | | |
| Character of the geotextile: | High tenacity polyester yarns woven textiles | | |
| Mechanical characteristics: | Tolerance range<br>Confidence level | = -10% of average (min value)<br>= 95% | |
| Nominal tensile strength (MD) | (kN/m) | ≥1000 | ISO 10319 |
| Nominal tensile strength (CMD) | (kN/m) | ≥100 | ISO 10319 |
| Tensile strength at 4% strain (MD) | (kN/m) | ≥285 | ISO 10319 |
| Tensile strength at 5% strain (MD) | (kN/m) | ≥420 | ISO 10319 |
| Strain at nominal tensile strength (MD) | (%) | ≤12 | ISO 10319 |
| Strain at nominal tensile strength (CMD) | (%) | ≤12 | ISO 10319 |
| Water permeability $Q_{100}$ | (m/s) | $>3 \times 10^{-3}$ | ISO 11058 |
| Creep limited strength based on creep-rupture at 60 years design life | (kN/m) | 709 | |
| Long term design strength in clay, silt or sand at 60 years design life | (kN/m) | 626 | |
| Material reduction factor creep-rupture at 60 years design life | | 1.41 | |
| Material reduction factor installation damage in clay, silt or sand | | 1.10 | |
| Material reduction factor environmental effects (4 < pH < 9) at 60 years design life | | 1.03 | |
| Material reduction factor – consistency of manufacture | | 1.00 | |

*The above are average values.*

# Custom-made Two-way Strength Woven Geotextile

Mirafi®

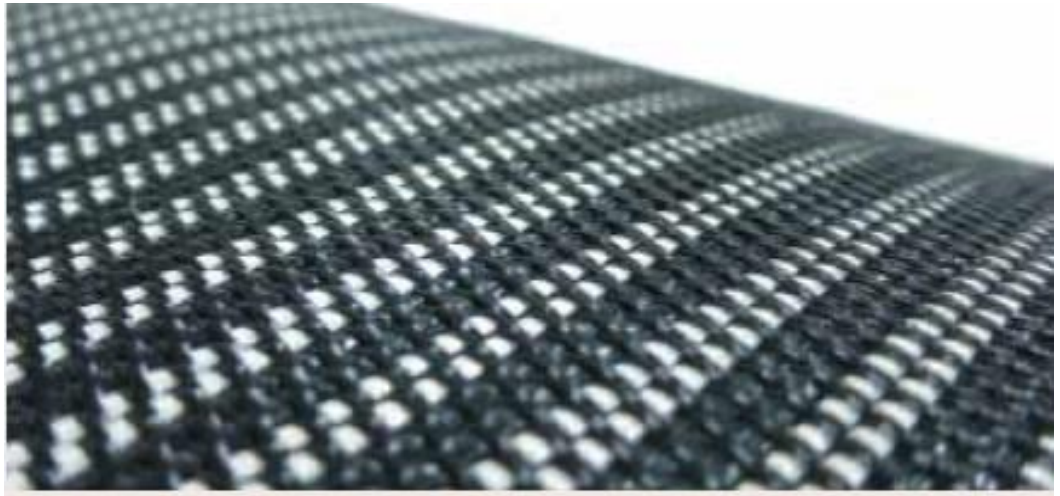
Sample

## TECHNICIAL DATA

| | |
|---|---|
| Date of issue: | 28 Apr, 2021 |
| Project title: | Contract 3405 Third Runway Concourse Foundation and Substructure Works |
| Product name: | **Mirafi® DL2-1000** |
| Manufacturer: | TenCate Industrials Zhuhai Co., Ltd |
| Character of the geotextile: | Two layers high tenacity polyester woven textile |
| Mechanical characteristics: | Tolerance range = -10% of average (min value)<br>Confidence level = 95% |

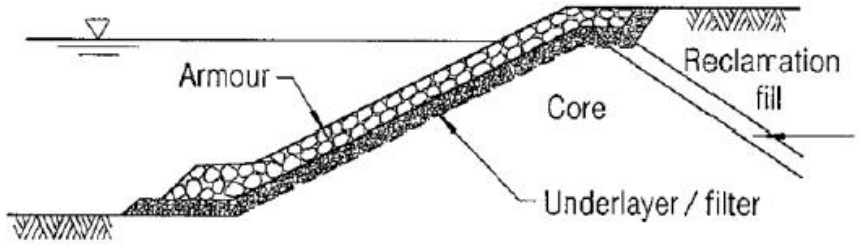
| | | | |
|---|---|---|---|
| Nominal tensile strength (Longitudinal) | (kN/m) | ≥1000 | ISO 10319 |
| Nominal tensile strength (Horizontal) | (kN/m) | ≥1000 | ISO 10319 |
| Strain at nominal tensile strength (Longitudinal) | (%) | ≤10 | ISO 10319 |
| Strain at nominal tensile strength (Horizontal) | (%) | ≤10 | ISO 10319 |
| Water permeability $Q_{100}$ | (m/s) | $>3 \times 10^{-3}$ | ISO 11058 |
| Creep limited strength based on creep-rupture at 60 years design life | (kN/m) | 709 | |
| Long term design strength in clay, silt or sand at 60 years design life | (kN/m) | 626 | |
| Material reduction factor creep-rupture at 60 years design life | | 1.41 | |
| Material reduction factor installation damage in clay, silt or sand | | 1.10 | |
| Material reduction factor environmental effects (4 < pH < 9) at 60 years design life | | 1.03 | |
| Material reduction factor – consistency of manufacture | | 1.00 | |

# Woven Geotextile Application



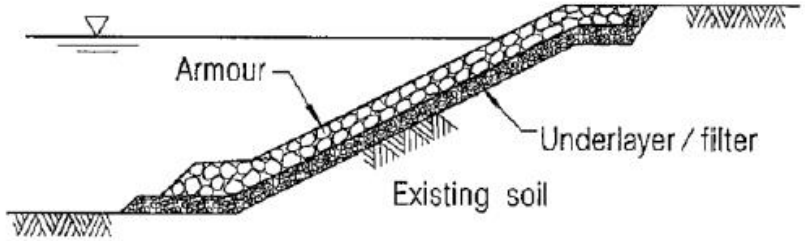
TenCate Mirafi® HPa *geotextile.*

# Port Works Elements – Seawall




(a) Rubble Mound Seawall for Reclamation

Filter layer
(If reclamation fill is used as core material, the filter layer behind the core will not be necessary)



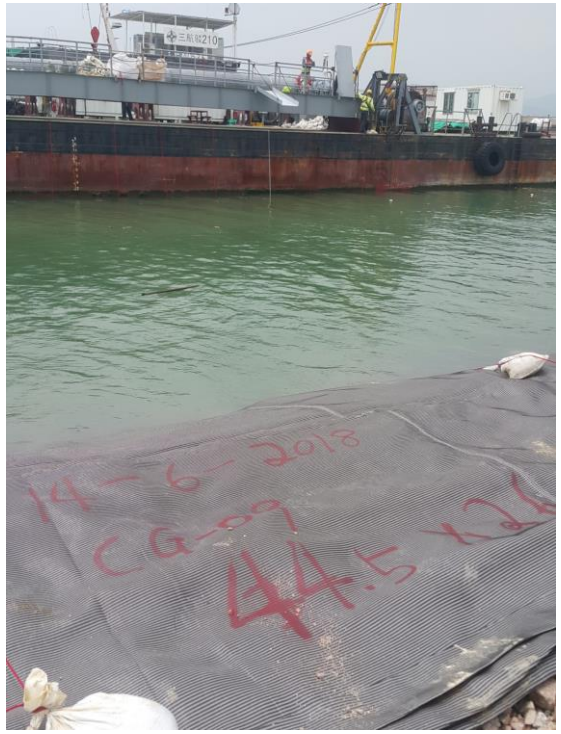

(b) Rubble Mound Seawall for Shore Protection

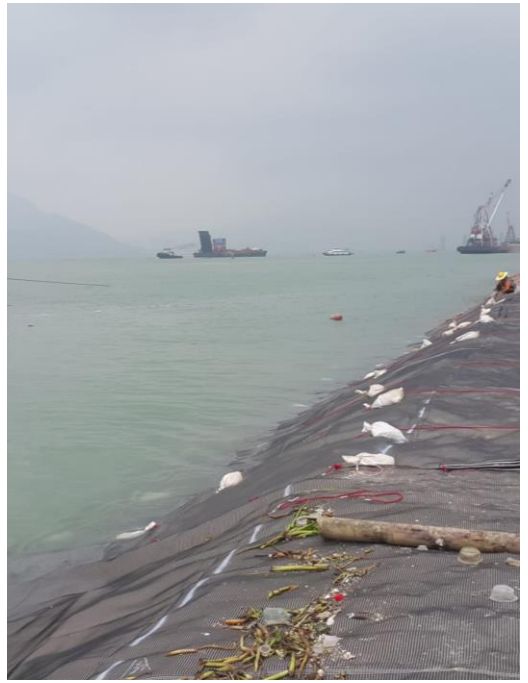
**Rubble Mound Seawalls**

# Sea Wall Protection

- Check product name and Specification
- Garp tensile test
- Long filament or Short Stable
- Check Product Pattern (Woven)
- Samples needed for each batch for Product test

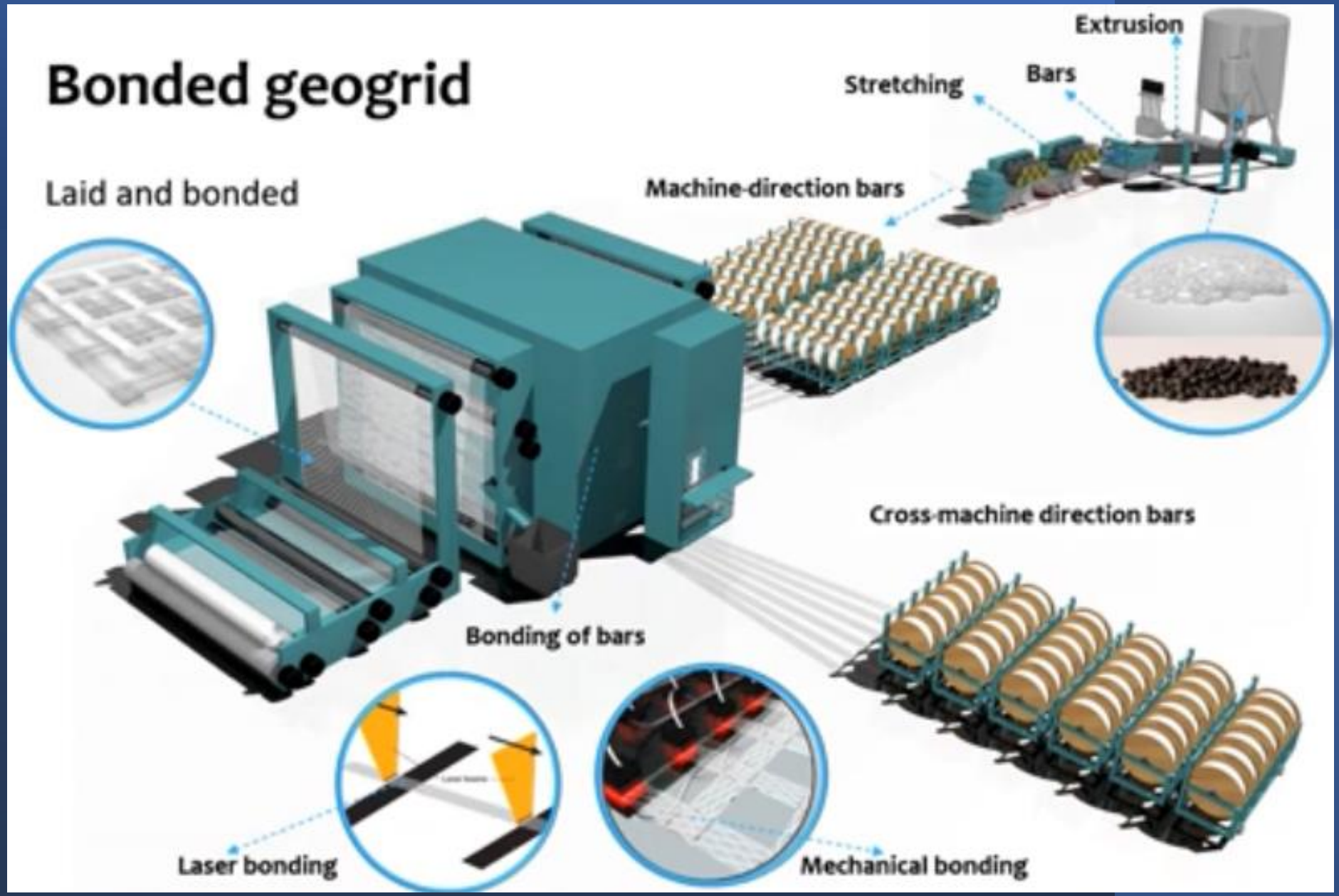

- 斜坡堤坡腳土工布鋪設使用鋪布船垂直於海堤方向自上而下一次鋪設完成，施工推進方向與海堤施工推進方向一致，当多個作業面開啟時，鋪布船喺各個作業面之間調度。
- 倒濾層土工布鋪設施工需結合坡腳土工布及土工格柵等各分項施工統籌安排人員、船機設備。 分兩次進行鋪設，先用鋪布船鋪設堤心石標高以下部分，待上部倒濾層及後方回填完成後再施工堤心石標高以上部分。 土工布鋪設單幅寬度為25.69m，長度13~16m，使用已縫製好的100m布在鋪布船上完成裁剪及摺疊





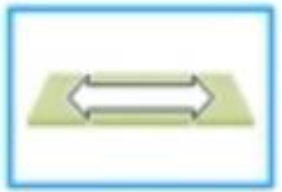

# Other Geotextile Type

- Planar, Permeable, Polymeric (Synthetic Or Natural) Material Used In Contact With Soil And Or Other Materials In Geotechnical And Civil Engineering Applications
- 在岩土工程和土木工程應用中用於與土壤和/或其他材料接觸的平面、可滲透、聚合物（合成或天然）材料


Bonded geogrid
Extrusion
Stretching
Bars
Laid and bonded
Machine-direction bars
Cross-machine direction bars
Bonding of bars
Laser bonding
Mechanical bonding

GX (Geogrid)

# Geogrids



- Reinforcement

- Stabilisation

Definition*

planar, polymeric structure consisting of a regular open network of integrally connected, tensile elements, which may be linked by extrusion, bonding, or interlooping or interlacing, whose openings are larger than the constituents

Extrusion

Bonding

Interlooping/-lacing

# Typical Technical Data for Geogrid

TenCate Miragrid®

GX800100-210901-00

## TECHNICAL DATA

| | |
|---|---|
| Date of issue: | 01 Sept 2021 |
| Project: | Contract 3310 North Runway Modification Works |
| Product: | **TenCate Miragrid® GX800/100** |
| Character of the geogrid: | High tenacity polyester geogrids with stable and high quality polymeric coating |

| | | | |
|---|---|---|---|
| Characteristic initial strength(md) | (kN/m) | 800 | ISO 10319 |
| Characteristic initial strength(cd) | (kN/m) | 100 | ISO 10319 |
| Strain at initial strength (md) | (%) | 15 | ISO 10319 |
| Strain at initial strength (cd) | (%) | 12.5 | ISO 10319 |
| Creep strain between 1 day & 120 yrs under a load of 50% of the Characteristic Tensile Strength in md | (%) | 1.0 | ISO 13431 |
| Creep limited strength (120 yrs design life) | (kN/m) | 559 | ISO 13431 |
| Long term design strengths (120 yrs design life) | | | |
| in clay, silt or sand | (kN/m) | 498 | |
| in aggregate base course | (kN/m) | 480 | |
| in well graded gravel | (kN/m) | 480 | |

| Partial reduction factors: | | |
|---|---|---|
| Creep rupture | = | 1.43 (120 years design life) |
| Construction damage | = | 1.06 (in clay, silt or sand) |
| | = | 1.10 (in aggregate base course, 32mm max size) |
| | = | 1.10 (in well graded gravel, 63mm max size) |
| Environment | = | 1.06 (120 years, 4 < pH < 9) |
| Material | = | 1.00 |

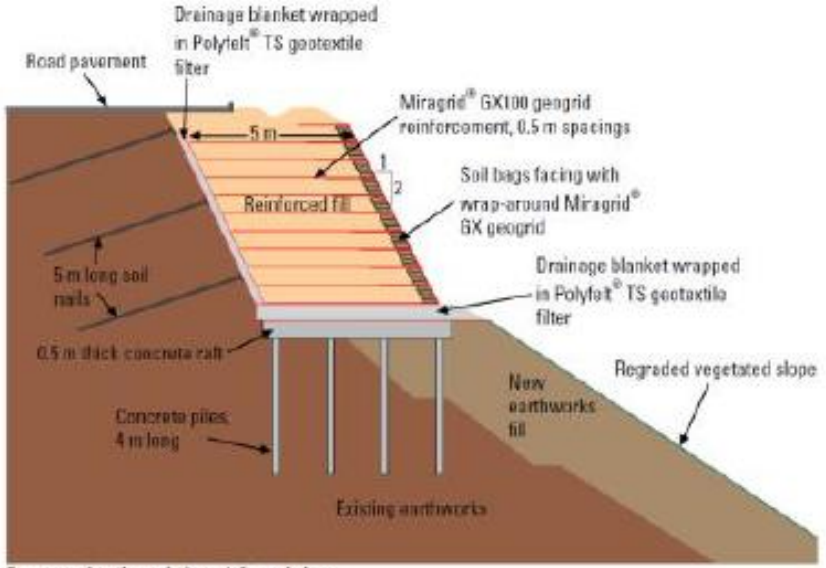
## Panipat Elevated Highway, India

The Panipat Elevated Highway Project involved the construction of a few flyovers along the way. Miragrid® GX geogrids ranging from 40 kN/m to 100 kN/m tensile strength used for the construction of segmental panel reinforced soil walls.

# Chiangmai Wat Phrathat Road Widening, Thailand

Due to high tourist and pilgrimage traffic the existing road leading up to the Wat Phrathat mountain temple in Chiangmai needs widening.

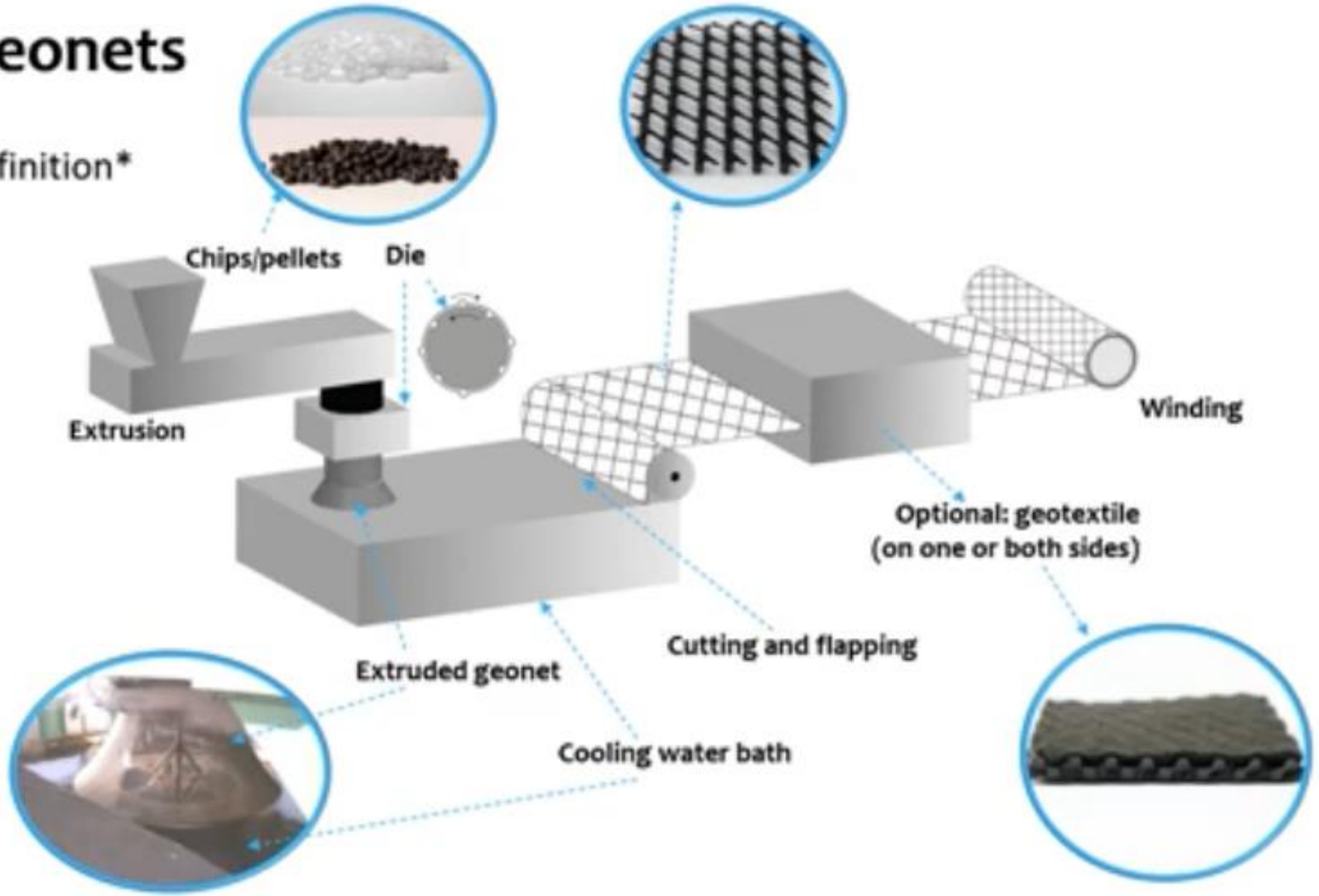
Miragrid® GX100 geogrid used to construct a reinforced steep slope to cater for the widening works.




Cross section through the reinforced slope

# Geonets

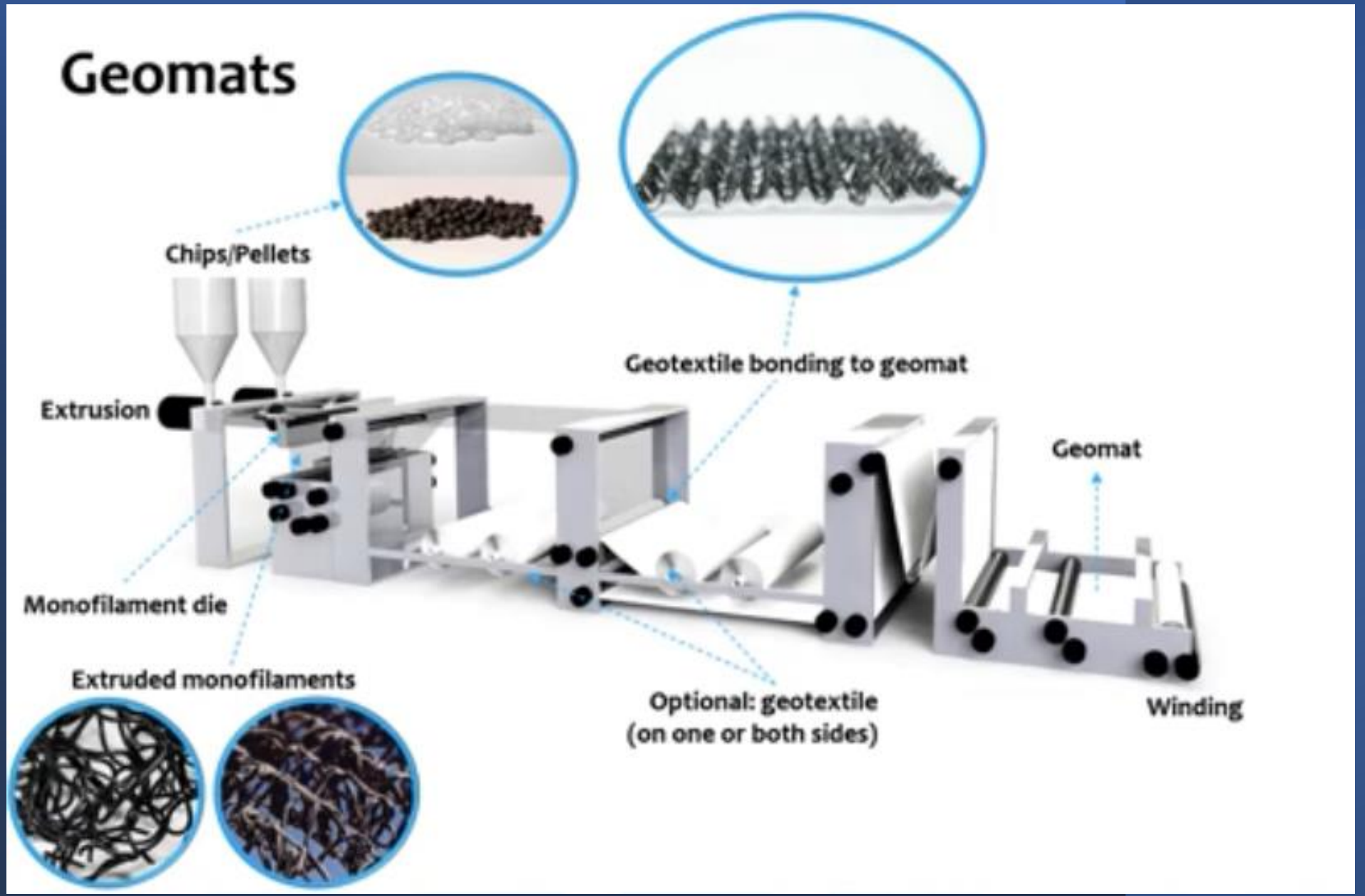
Definition*



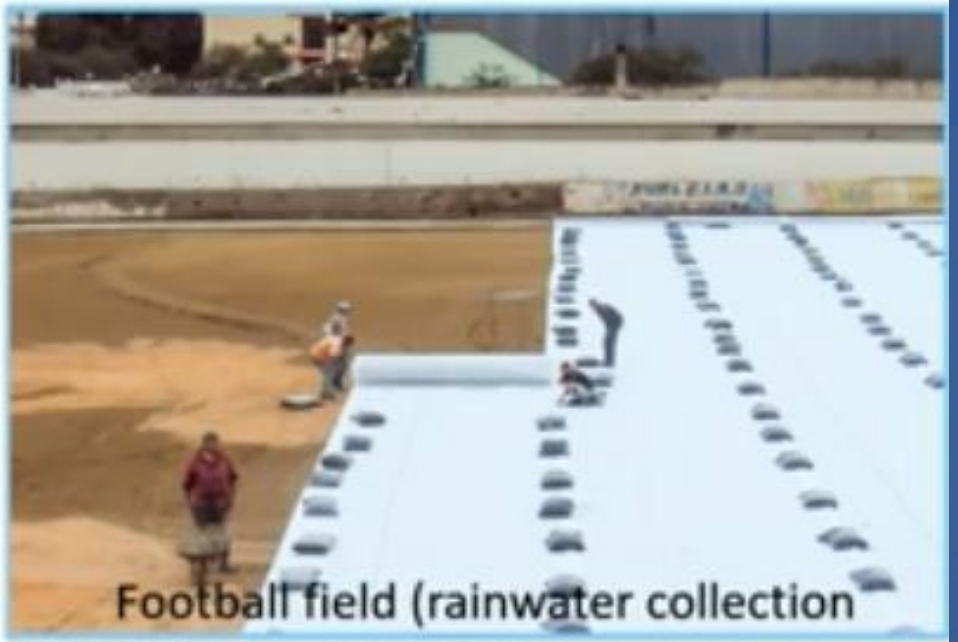
# Typical geonet application




# Geomats


Chips/Pellets
Extrusion
Monofilament die
Extruded monofilaments
Geotextile bonding to geomat
Geomat
Optional: geotextile
(on one or both sides)
Winding

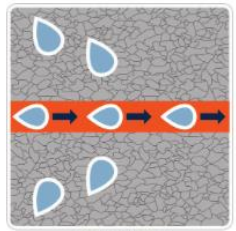
# Typical geomat application



# Vertical Drain Board Application

- Vertical drain board are mostly used to shorted the settlement period and thus reduce the construction period of a project, and to avoid post-construction differential settlements.



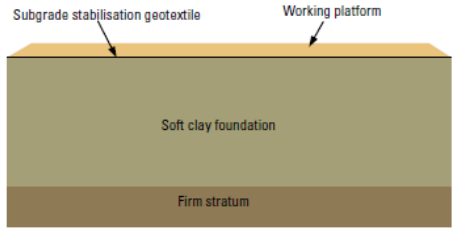
DRAINAGE

Drainage

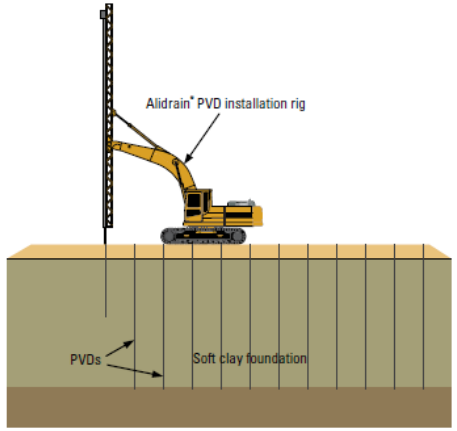
The major function of draining is to evacuate water or other liquids towards the structure's outlets.

# Functional Application – Transmit Water

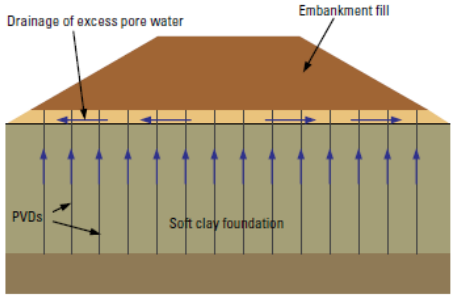
## Polyfelt® Alidrain PVDs




a) Construction of working platform on top of soft clay foundation



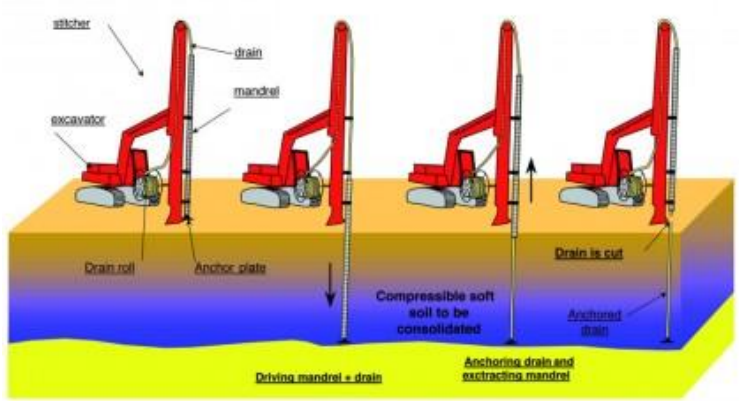

b) Installation of Alidrain® PVDs into soft clay foundation




c) Drainage of excess pore water from soft clay foundation

PVD

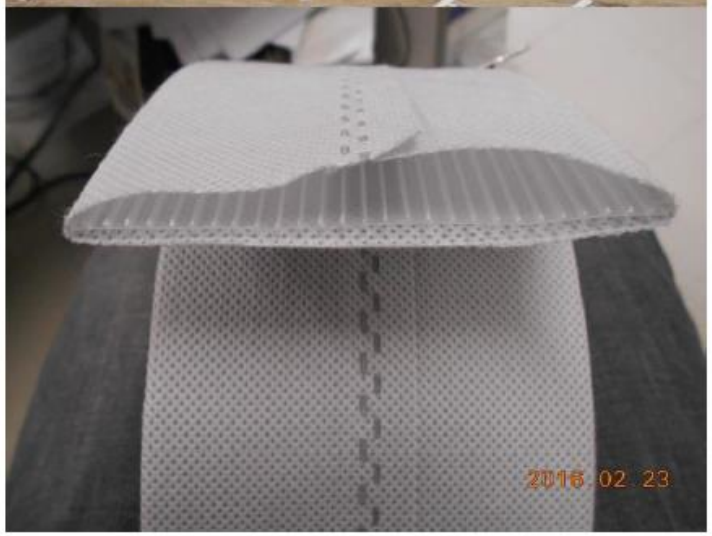
Metal shoe




PVD installation sequence

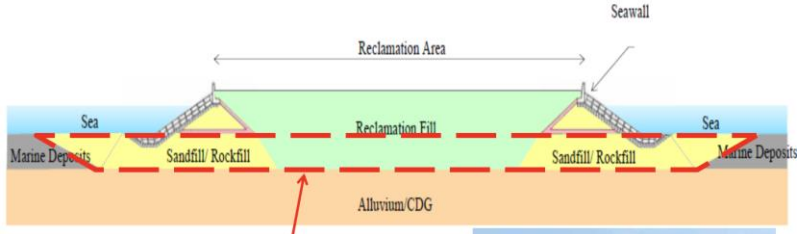
PVD installation in progress

# Reclamation – Vertical Drain


# Band Drain Method Development

**Fully dredged method to reduce settlement**

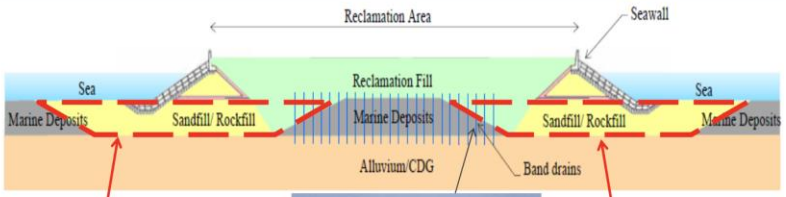



Fully dredged seawall foundation and reclamation area

*Sand filling*

7

**Partial dredging, band drains & surcharging to speed up settlement**




Fully dredged seawall foundation

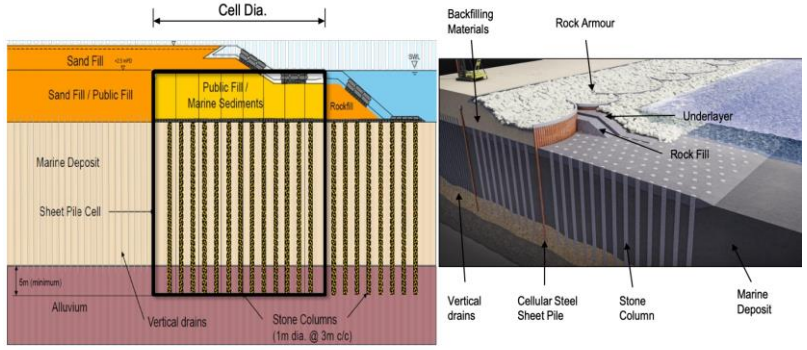
Fully dredged seawall foundation

Band drains & surcharging were used to speed up consolidation of the left-in-situ marine deposits at the main reclamation

8

**(1) Addressing the Environmental Concerns**

(c) Minimize Impact on water quality and ecology by using advanced reclamation method and technology – non dredged method




Schematic Layout

Isometric View

*Source: Hong Kong Boundary Crossing Facilities, Hong Kong–Zhuhai-Macao Bridge, Highways Department*

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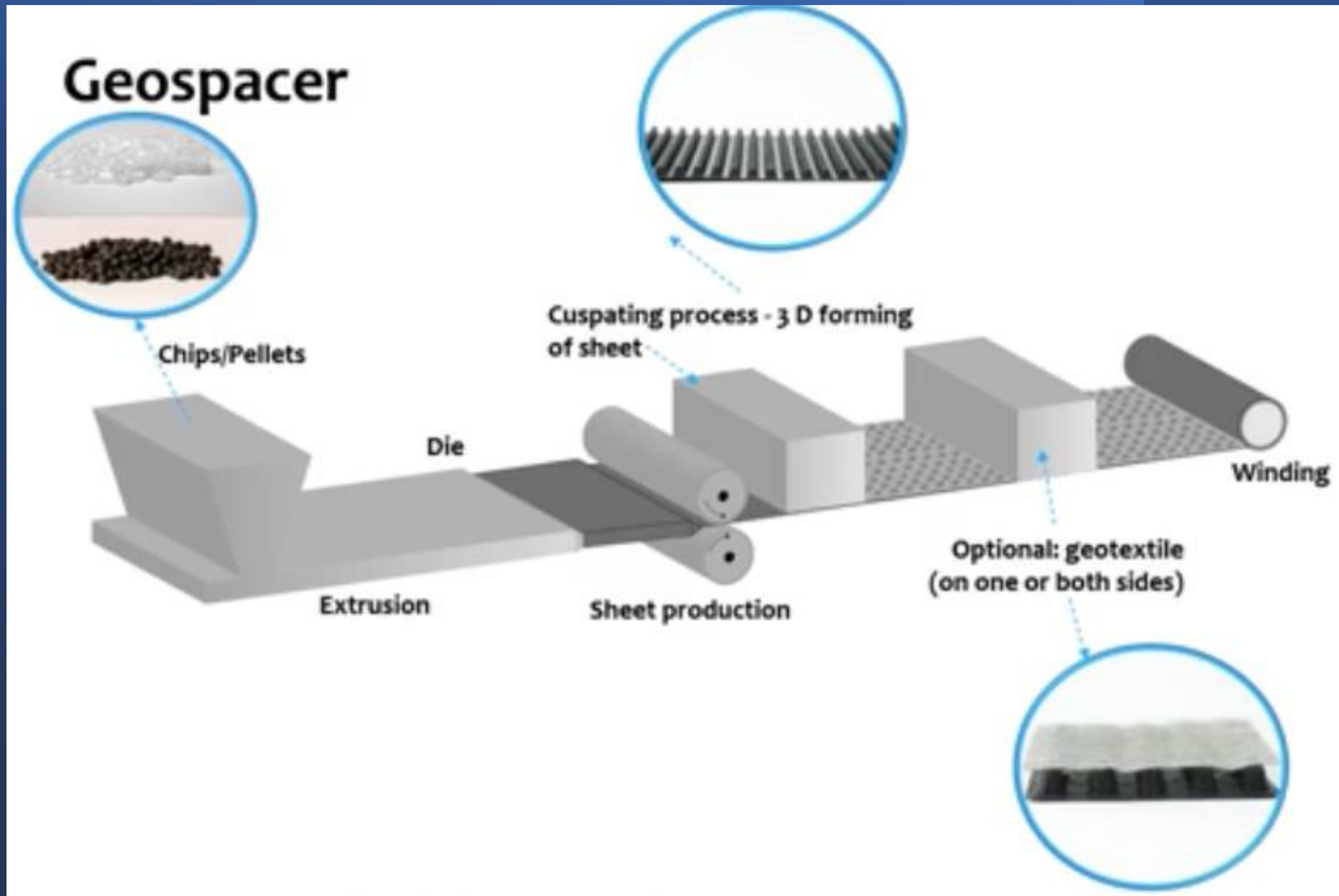
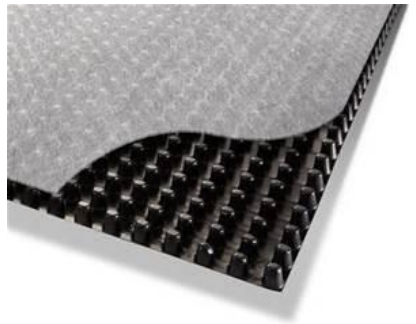
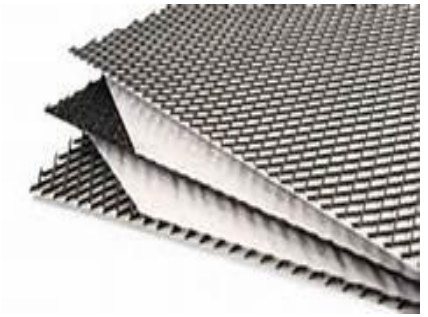
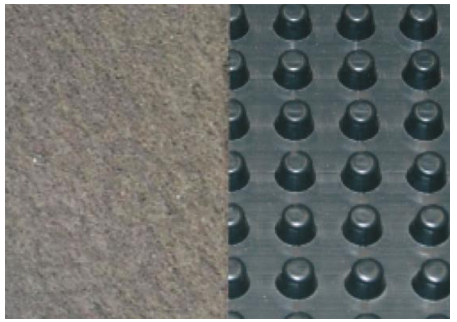
Challenges In Hong Kong Land Supply By Reclamation by Ir. Robin Lee Kui Biu 2014

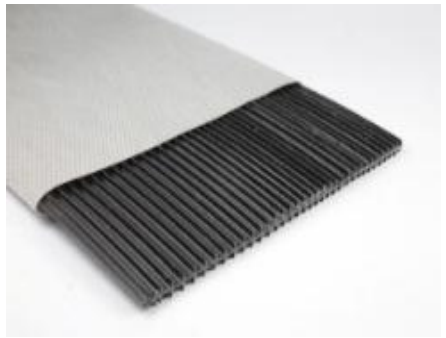
# Geospacer


Chips/Pellets
Cuspating process - 3 D forming of sheet
Die
Winding
Optional: geotextile (on one or both sides)
Extrusion
Sheet production

- Geocomposite drains or geodrains compose of A polymer core (net, mesh, structured sheet, etc.) And one or two filter geotextile
- Geodrains may come as A sheet or strip form
- The purpose of the geotextile is to allow water to pass through but prevent excessive soil entering to clog up the drainage core in the long run
- The purpose of the core is to transmit water within the plane of the core



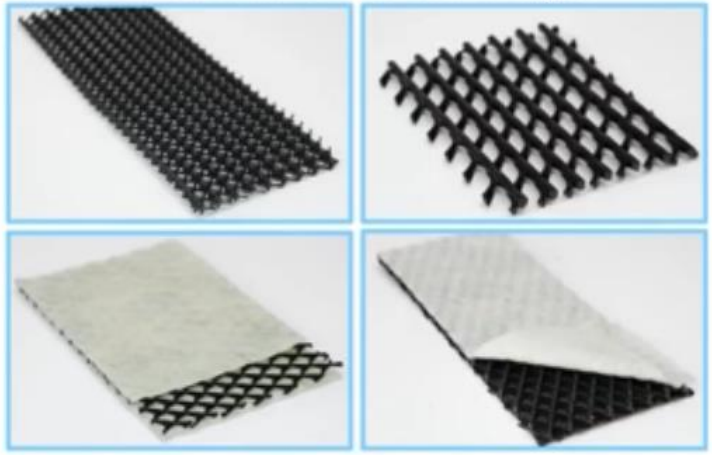


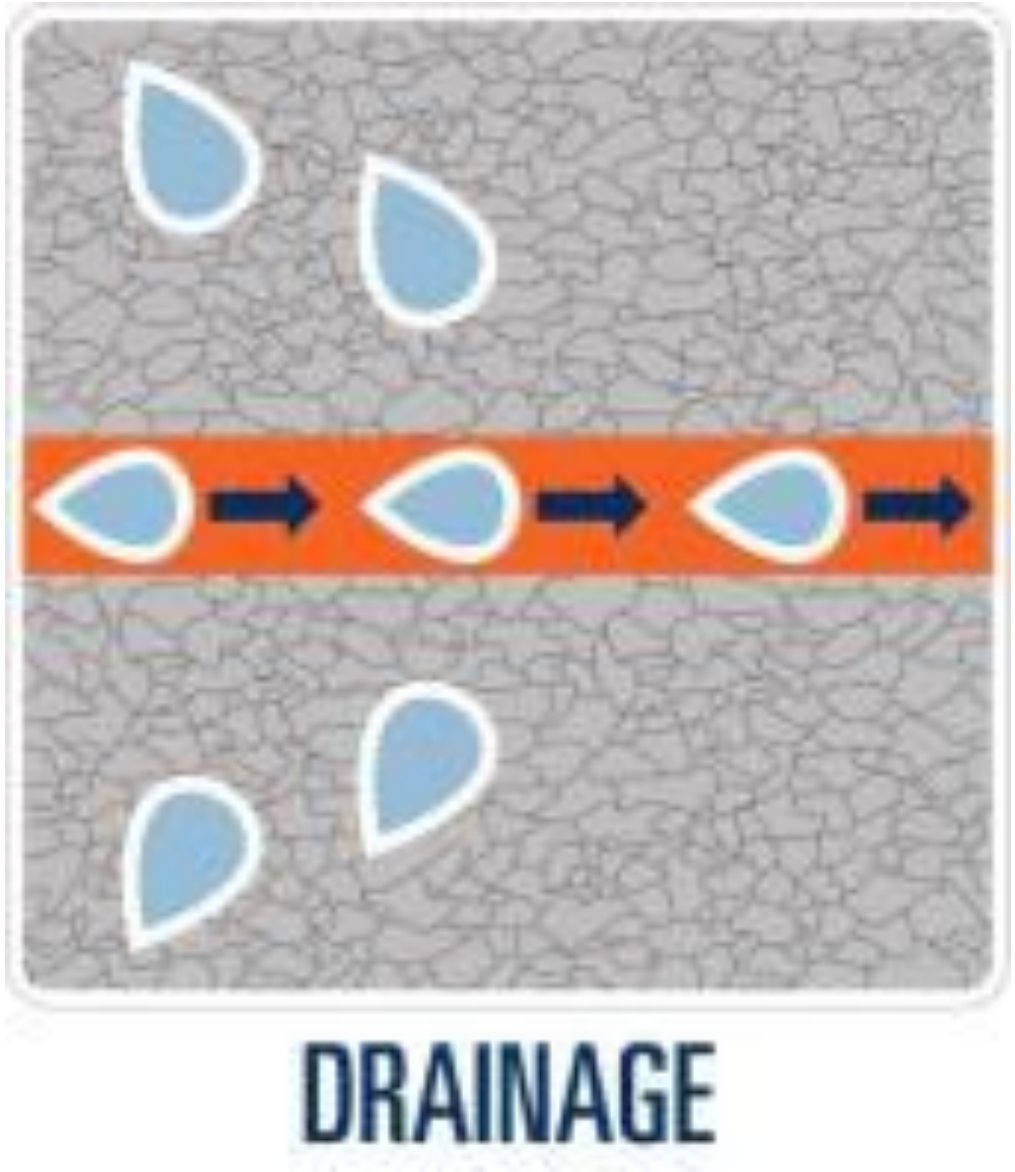
## Geonets

- Drainage

Definition*

geosynthetic consisting of parallel sets of ribs overlying and integrally connected with similar sets at various angles





# HDPE Flow board /Woven / Non-woven

Comparison of material specification:

**PHD2 FW400/007 - Technical Data Sheet**

| PROPERTY | TEST METHOD | VALUE | METRIC UNITS | | |
|---|---|---|---|---|---|
| **CORE (Cuspated)** | | | | **Performance** | **Comparison MiraDrain (G100W)** |
| Thickness | ASTM D1777 | Average | mm | 15 | 10 |
| Comprehensive Strength | ASTM D1621(mod) | Average | kPa | 800 | 860 |
| Maximum Flow Rate<br>In plane flow rate @ gradient of 1.0 | ASTM D4716 | Average | l/min/m | 360 | 260 |
| Installed Horizontally<br>Installed flow rate with soil overburden @ gradient of 1.0 | ASTM D4716 | Average | l/min/m | 60 | 47 |
| Installed Vertically<br>Installed flow rate with soil overburden @ gradient of 1.0 | ASTM D4716 | Average | l/min/m | 310 | 224 |
| **FW Mono/Mono Filament Woven Filter (Tencate Fabrics)** | | | | | |
| | | | | FW400 | SP007 |
| Apparent Opening Size | ASTM D4751 | Average | mm | 0.35 | — |
| Mean Flow Rate $O_{50}$ | ISO 11058 | Average | $l/m^2/s$ | 50 | — |
| Grab Tensile Strength | ASTM D4632 | Average | kN | 35 | 34 |
| Grab Elongation | ASTM D4632 | Average | % | 20 | 75 |
| Puncture Strength | ASTM D4833 | Average | kN | 4.0 | 5.8 |
| Opening size $O_{90}$ | ISO 12956 | Average | mm | — | 0.10 |
| Opening size, $O_{90}$ (modified) | ISO 12956 | Average | mm | — | 0.11 |
| Water permeability, $O_{50}$ | ISO 11058 | Average | m/s | -- | $5*10^{-5}$ |
| **SYSTEM** | | | | | |
| Performance Index | ASTM D4833, D4632 & D1621 | Average | — | 18250 | |

Note: For Subsurface drain, If the core panels require cutting, exposed cuts must be covered with supplemental pieces of filter fabric to prevent soil intrusion. A minimum 6" (150 mm) piece of filter fabric will be required to cover cut sections.

Ref:


(1) Planning Application for Proposed Temporary Transitional, Housing Development at Lot 2160 RP (Part) in D.D. 106 and Adjoining Government Land, in Kam Tin, Yuen Long, New Territories (Sept 2021)

(2) Landscape master plan for S12A planning application, HKU, Capital Development Complex at Pokfield Road Site (July 2021).

# Testing of Geocomposite PHD-2

# Geo Composite System – PHD2

- Three-dimensional polymeric structure with an interconnected air space in between, used in contact with soil and/or other materials in geotechnical and civil engineering applications
- 三維聚合物結構，其間具有相互連接的空氣空間，用於在岩土工程和土木工程應用中與土壤和/或其他材料接觸

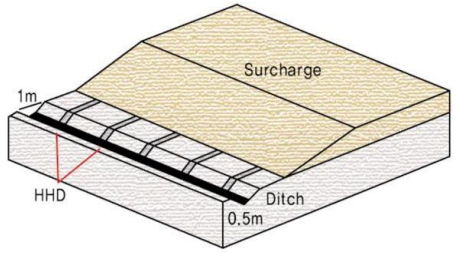
| PROPERTY | TEST METHOD | VALUE | METRIC UNITS | | |
|---|---|---|---|---|---|
| **Cuspated HDPE Core 800** | | | | | |
| Thickness | ASTM D1777 | Average | mm | 15 | |
| Comprehensive Strength | ASTM D1621(mod) | Average | kPa | 800 | |
| Maximum Flow Rate<br>In plane flow rate @ gradient of 1.0, 0.5, 0.1 | ASTM D4716 | Average | l/min/m | 360, 270, 60 | |
| Installed Vertically<br>Installed flow rate with soil overburden @ gradient of 1.0, 0.5, 0.1 | ASTM D4716 | Average | l/min/m | 310, 230, 50 | |
| **SP007 Continuous Filament Nonwoven Filter / FW400 Mono Filament Woven Filter** | | | | | |
| | | | | FW400 | SP007 |
| Apparent Opening Size | ASTM D4751 | Average | mm | 0.35 | — |
| Mean Flow Rate $O_{50}$ | ISO 11058 | Average | $l/m^2/s$ | 50 | — |
| Grab Tensile Strength | ASTM D4632 | Average | kN | 35 | 34 |
| Grab Elongation | ASTM D4632 | Average | % | 20 | 75 |
| Puncture Strength | ASTM D4833 | Average | kN | 4.0 | 5.8 |
| Opening size $O_{90}$ | ISO 12956 | Average | mm | — | 0.10 |

# Sumatera Toll Road (Toll Kayu Agung to Palembang Section II)

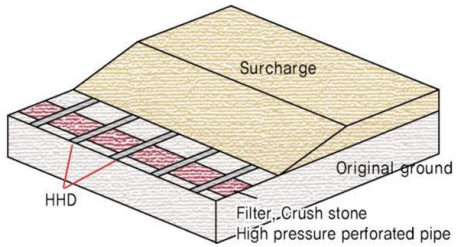
Toll Kayu Agung – Palembang is a part of Mega Project Toll Trans Sumatera which connects Aceh Province in Northern Sumatera to Lampung in Southern Sumatra with total length 2.818 km. We have supplied 3.4 million linear meter PVD AD230 up-to-date. Vacuum consolidation technique is adopted to accelerate progress and shorten the surcharging period of soft ground to 1.5months.

# Application of Geo Composite

Collecting water method with HHD




Ditch




Filter, Crush stone, High pressure, Perforated pipe

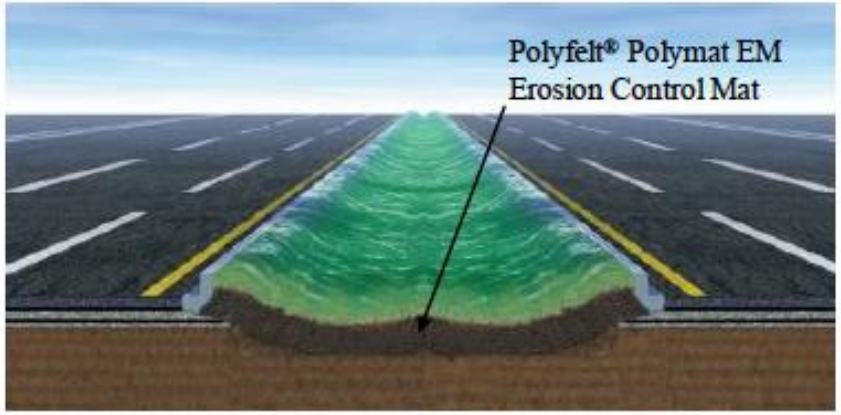
# 8號幹線青衣北繞道与南灣隧道 (2008)

# KL Cyber Village, Malaysia

Heavy thunderstorms frequently give rise to short duration but intense surface runoffs.

Polyfelt® Polymat EM erosion control mat reinforces turf to provide enhanced resistance against runoff erosion.

About 50,000 $m^2$ of Polyfelt® Polymat EM erosion control mat used to line swales.





# Sample of GeoTube® Application in Hong Kong

2 Days

# From Saturday to Monday

# Melaka River Environmental Dredging, Malaysia

Melaka River was dredged as part of a major remediation and beautification program.

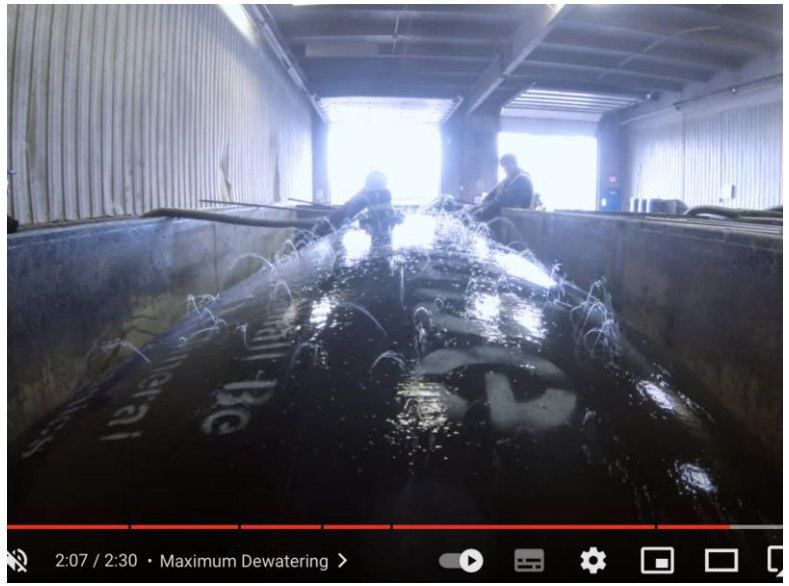
Geotube® GT500D dewatering containers used for dewatering of dredeged sediments to reduce volume and achieve a dryness that allowed the material to be transported away using standard haul trucks.

# PEMEX Gas, Campeche, Mexico

Rock dropping was not allowed due to the presence of a gas pipeline.

Geotube® GT500M units filled in-situ with sulfate resistant hydraulic marine concrete used as armour protection to wharf to form 20T armour units.

# Successful Example for Geo Bag Application




# Example of Using Geotube® For Dewatering

# Kai Tak Channel Environmental Dredging, Hong Kong

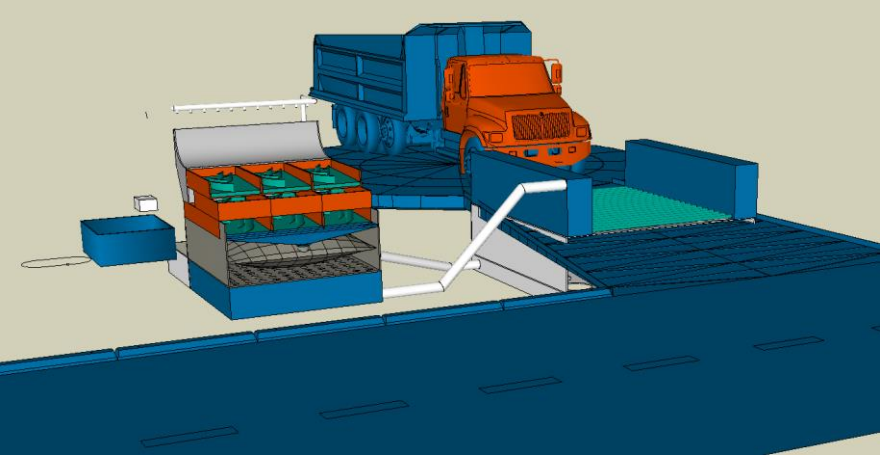
The Kai Tak Approach Channel contains contaminated sediments on the seabed.

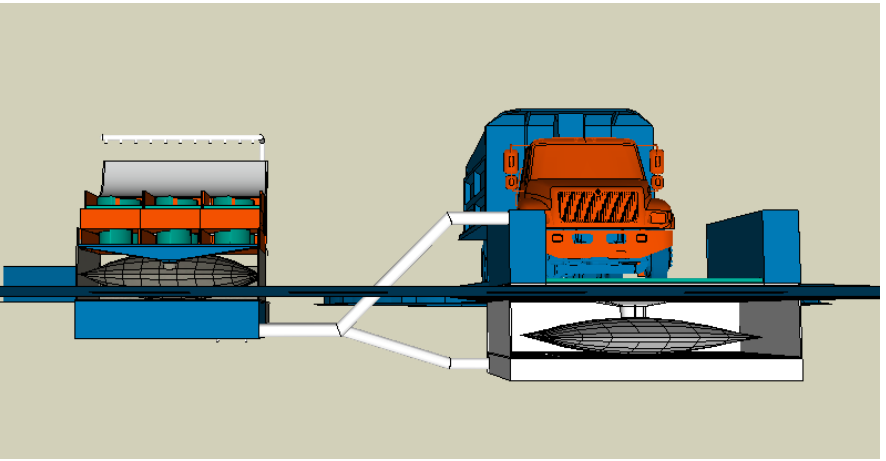
800 units of Geotube® GT1000M containers used for disposal of 120,000 $m^3$ of Type 3 contaminated sediments at the East Sha Chau contaminated mud pits.

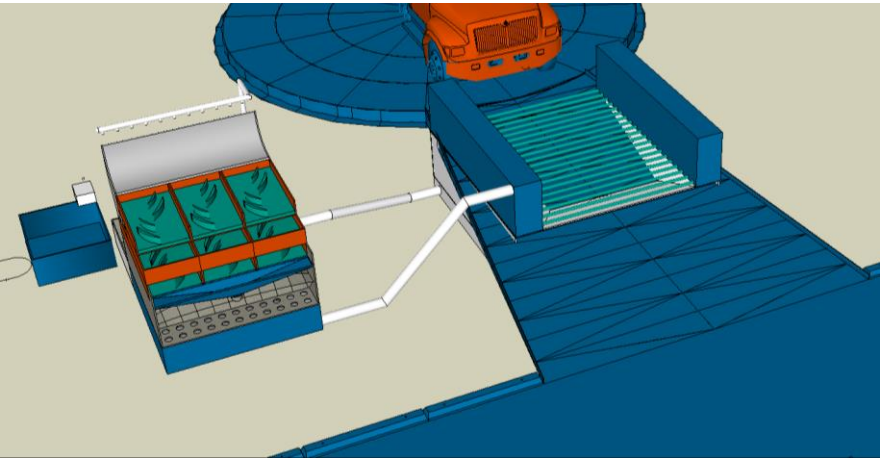
# Wan Chai Geo Container Application


# Sea Wall Protection


# Existing Brand in the Market for Slurry Separator







# New Design Concept

- Minimum spacing require on site
- One Equipment size for Any size of Geo Bag
- Large storage of dewatered Geo Bag
- All Dry solid remain on site
- Minimum moving parts design, less maintenance cost
- Minimum cost, we can provide module, or on-site design to suit different site condition.
- Custom design Polymer for different media

# Innovation with Geo Bag – Woven / Nonwoven Geotextile make it into a bag for Soil/Water Separation

- Testing of different Geotextile with different Polymer
- Using combination of Woven and Non-woven
- Develops the best combination of geotextile bag for every single job condition.

# Causing by Heavy Rain?

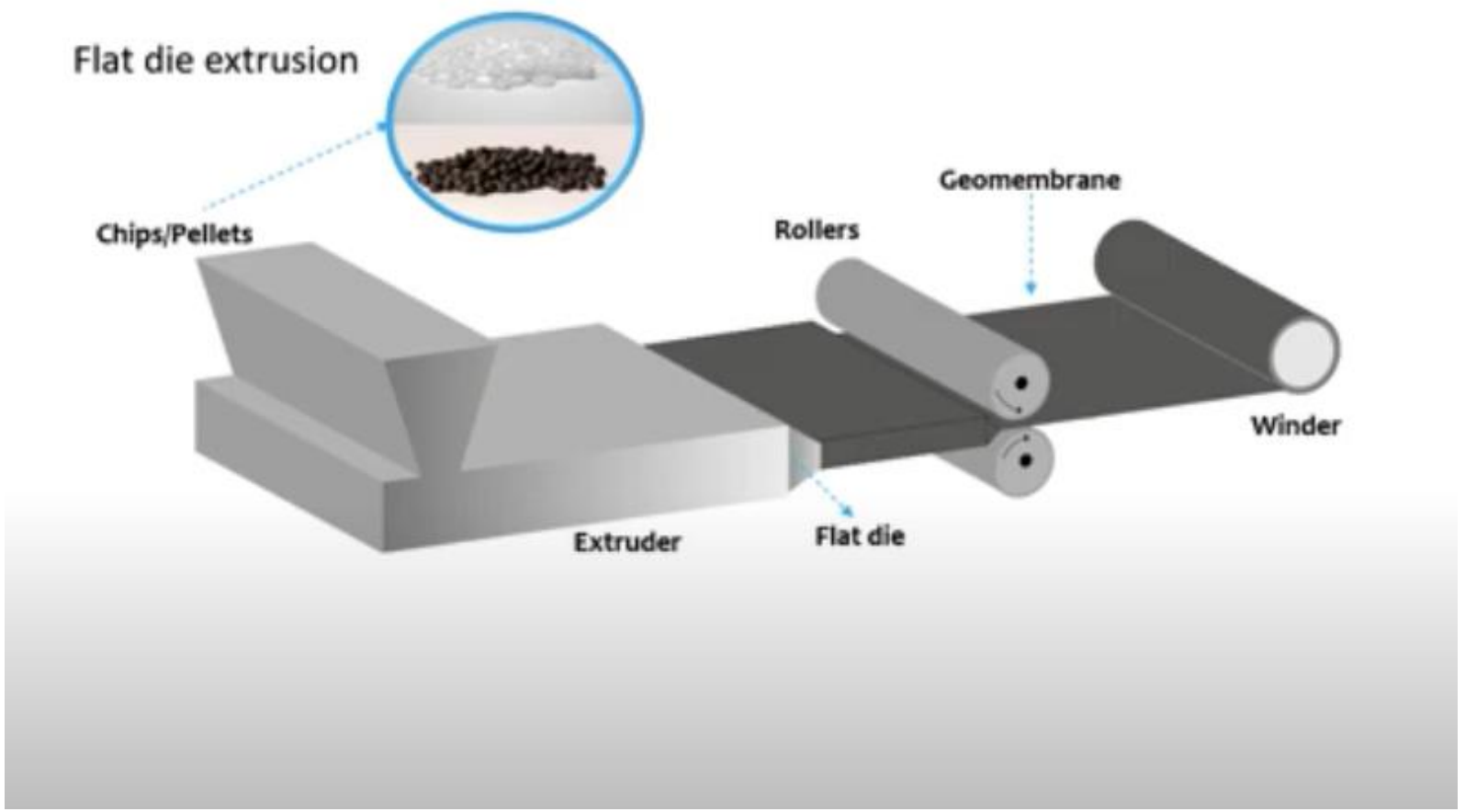
- Can we Prevent it?
- How?

# HDPE Geo Membrane

Geosynthetics

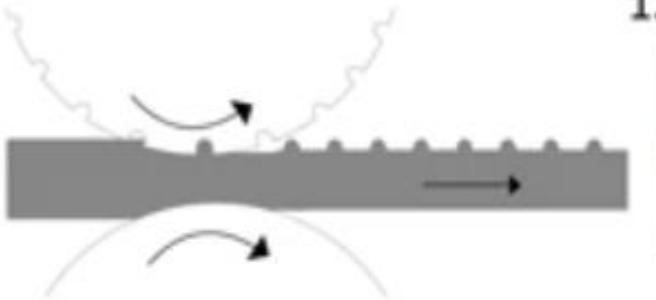
Impermeable

# Geomembrane



# Geomembrane surface structure

1. Embossing or structuring



Created by extruding molten material between two engineered rollers; core thickness of the geomembrane is not affected

*2. Impingementing*

Hot particles are projected onto the previous manufactured smooth sheet

*3. Co-extrusion*

Injection of nitrogen into the liner at the die

# Polymeric geosynthetic barriers

- Barriers

Definition*

Geomembrane - factory-assembled structure of geosynthetic materials in the form of a sheet in which the barrier function is essentially fulfilled by polymers

# CRACKS INSIDE WALL OF NON-PE-RC PIPE (PE100+ PIPE UNDER POINT LOAD)

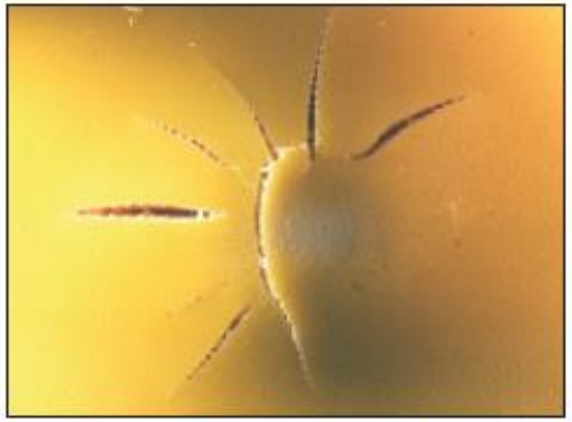


**Fig. 10**: Cracks in the inside wall of a PE 80 pipe subjected to an external point load and internal pressure (Test series 4)

**Fig. 12**: Cracks at the inside wall of a PE 100 pipe subjected to an external point load and internal pressure (Test series 6)

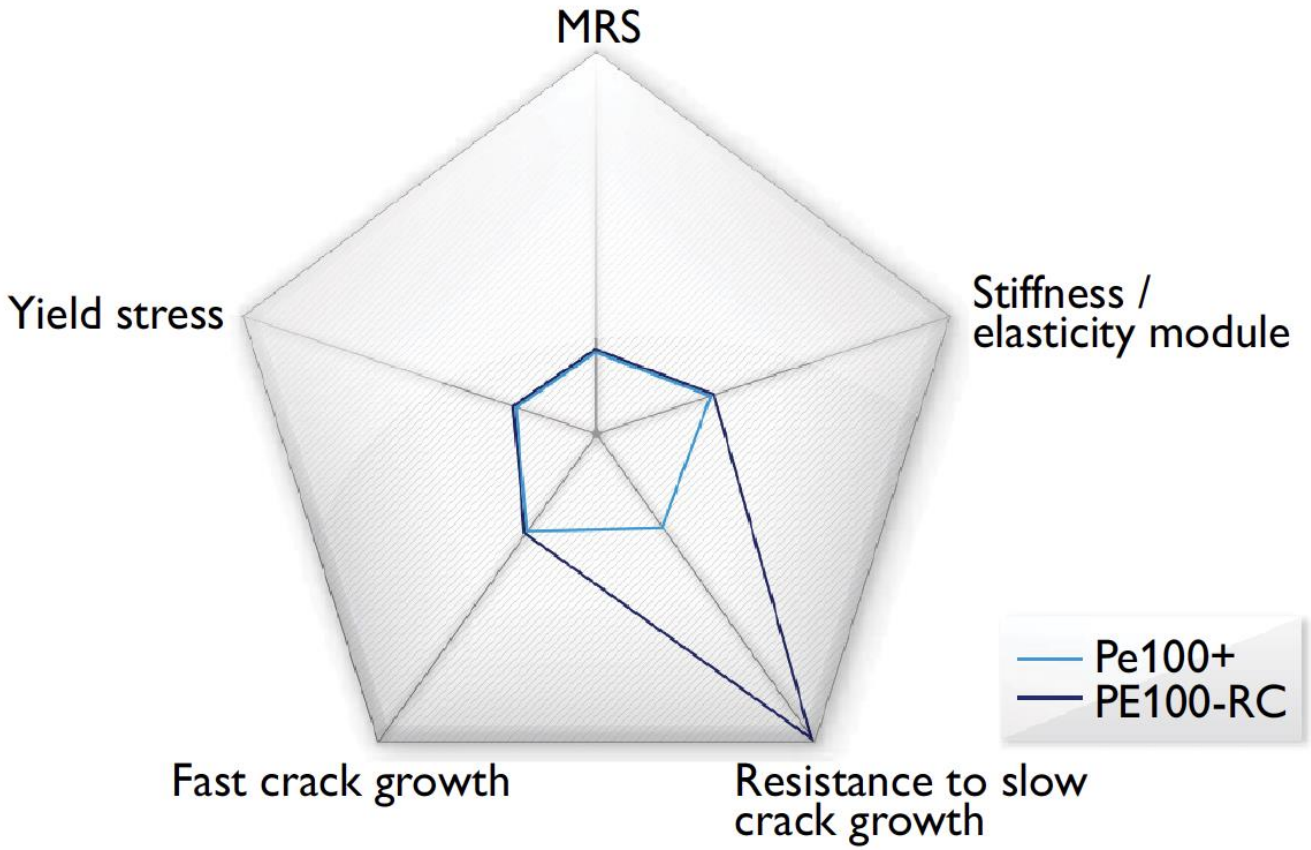
**Fig. 11**: Cracks at the inside wall of a PE 100 pipe subjected to an external point load and internal pressure (Test series 8)

**Fig. 13**: Cracks at the inside wall of a PE 100 subjected to an external point load and internal pressure (Test series 7)

# PE100 vs PE100 RC

Under FNCT Test (4Mpa,2% Arkopal N100, 80°C)

- PE100+ > 1000hr
- PE100 RC => 8760hr



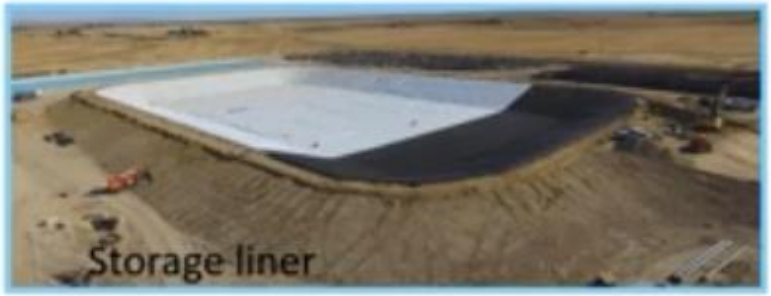

Comparison PE 100 and PE 100-RC

# Geo Membrane


HDPE Membrane

# Typical geomembrane application



# Example for Landfill Liner by Geo Composite


**C – Geo Composite PHD-2 (reduce 200mm thickness)**

- Horizontal drain board
- Non-Woven cushion

**B - Geomembrane/ Clay Layer**

- HDPE Membrane
- Bentonite

**A – Geo Composite PHD-2 (reduce 200mm thickness)**

- Non-Woven
- Horizontal drain board
- Non-Woven

**Sub Soil**

- Geo Grid

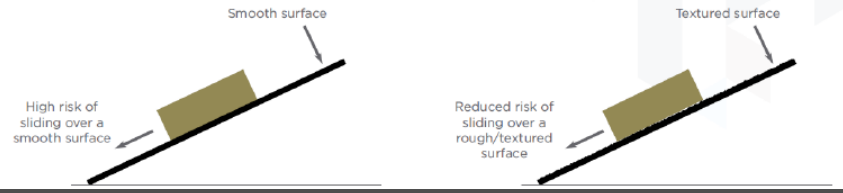
Ref: HK WENT Landfill Liner System

# Selection of HDPE Geomembrane on Slope

- Smooth liners are limited with regard to slope performance.
- The most critical sliding mechanism occurs along the interface plane of geosynthetics
- Hence, interface shear resistance of geomembrane is utmost important, and need engineers' attention to ensure a safe, stable with continuing operation of water containment.

# Why do Engineers Choose Textured Liner ?

- Geomembrane installed on slope must be able to:
  1) Support its own weight on the side slope
  2) Withstand down-dragging during and after placement of the overburden (e.g. cover soils/ wave force in the case of water pond)
  3) Maintain a stable state when a soil cover or a granular layer is placed on top of the geomembrane, if any.
  4) Maintain a stable configuration when other geosynthetics or subsoil movement




# 沉箱建造程(科威預廠記錄)

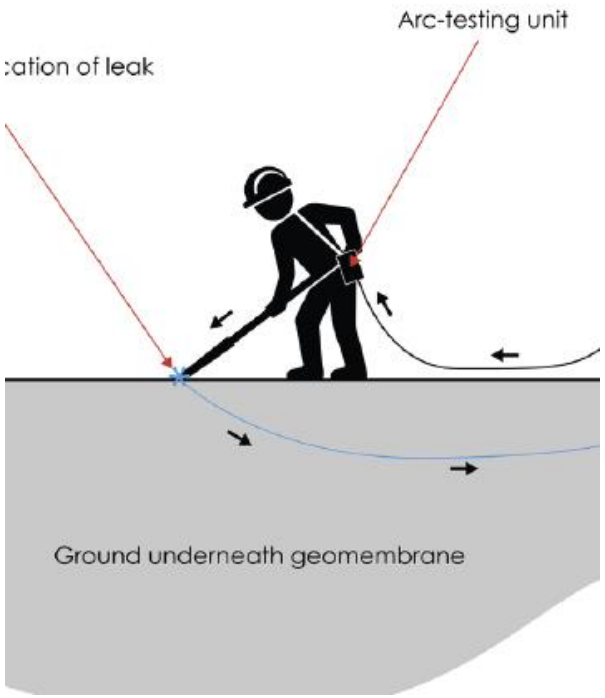


# 下城門水塘

# Geomembrane Welding Metod

# Geomembrane Welding and Testing

e, quickly produced with the




# Functional Application

## Barrier and barrier protection function

# Geo Clay Liner - GCL

## Geosynthetics

## Impermeable

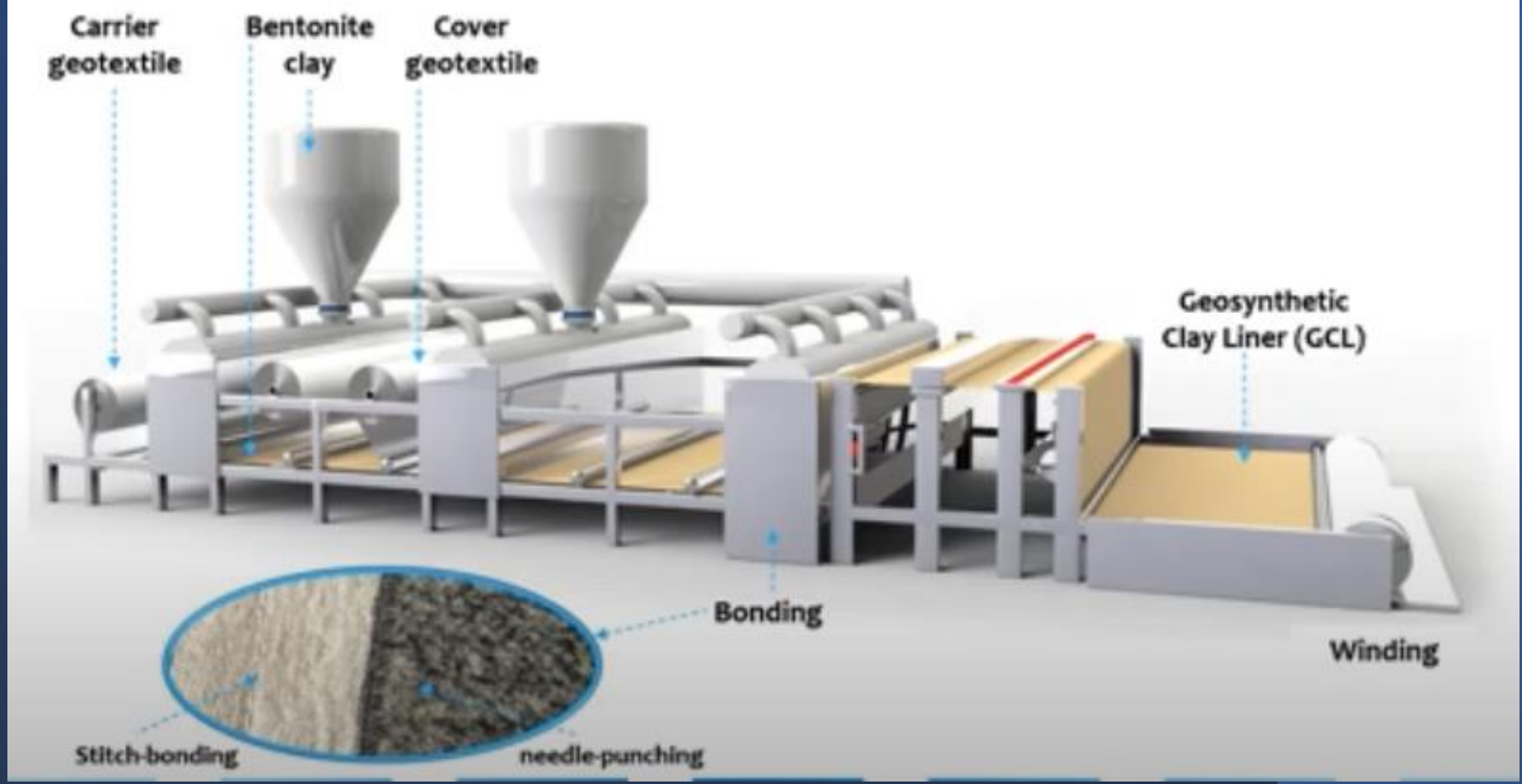
## Geotextiles Barriers

Low permeability geosynthetic material, used in geotechnical and civil engineering applications with the purpose of reducing or preventing the flow of fluid through the construction.

# Functional Requirement of Barrier Layers in Liner System
# 阻擋層的功能要求

| | |
|---|---|
| Should withstand loads due to moving men and machines as well as stresses due to waste | • Adequate puncture resistance<br>• 足夠的抗穿刺性<br>• Adequate tear resistance<br>• 足夠的抗撕裂性 |
| Should be easy to construct with existing technology | • Should be joinable<br>• Should be repairable<br>• 可以修復<br>• Should be self-healing<br>• 可以自愈 |
| Should be amenable to quality check after construction | • On-site “leak-proof’ checks : quality control tests<br>• 防漏檢查 |
| Should not slip along slopes | • High Resistance liner<br>• 高阻力 |

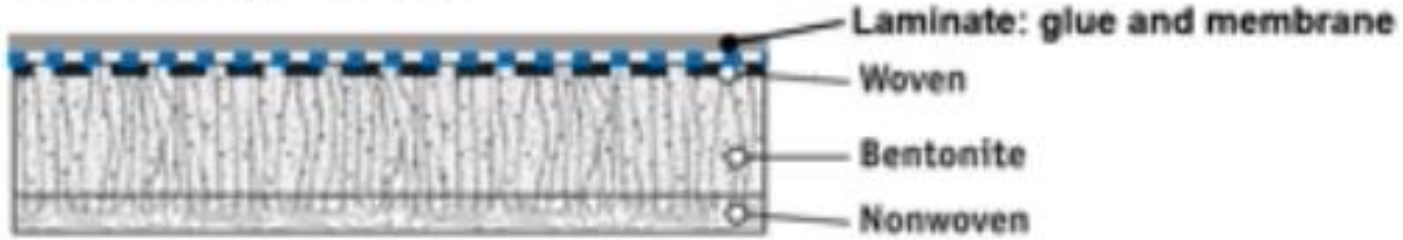
# Geosynthetic clay liner



# Multi-component GCL

Definition*

laminated GCL, n—GCL product with at least one film or membrane layer superimposed and bonded to the GCL by an adhesive (e.g. glue) usually under heat and pressure

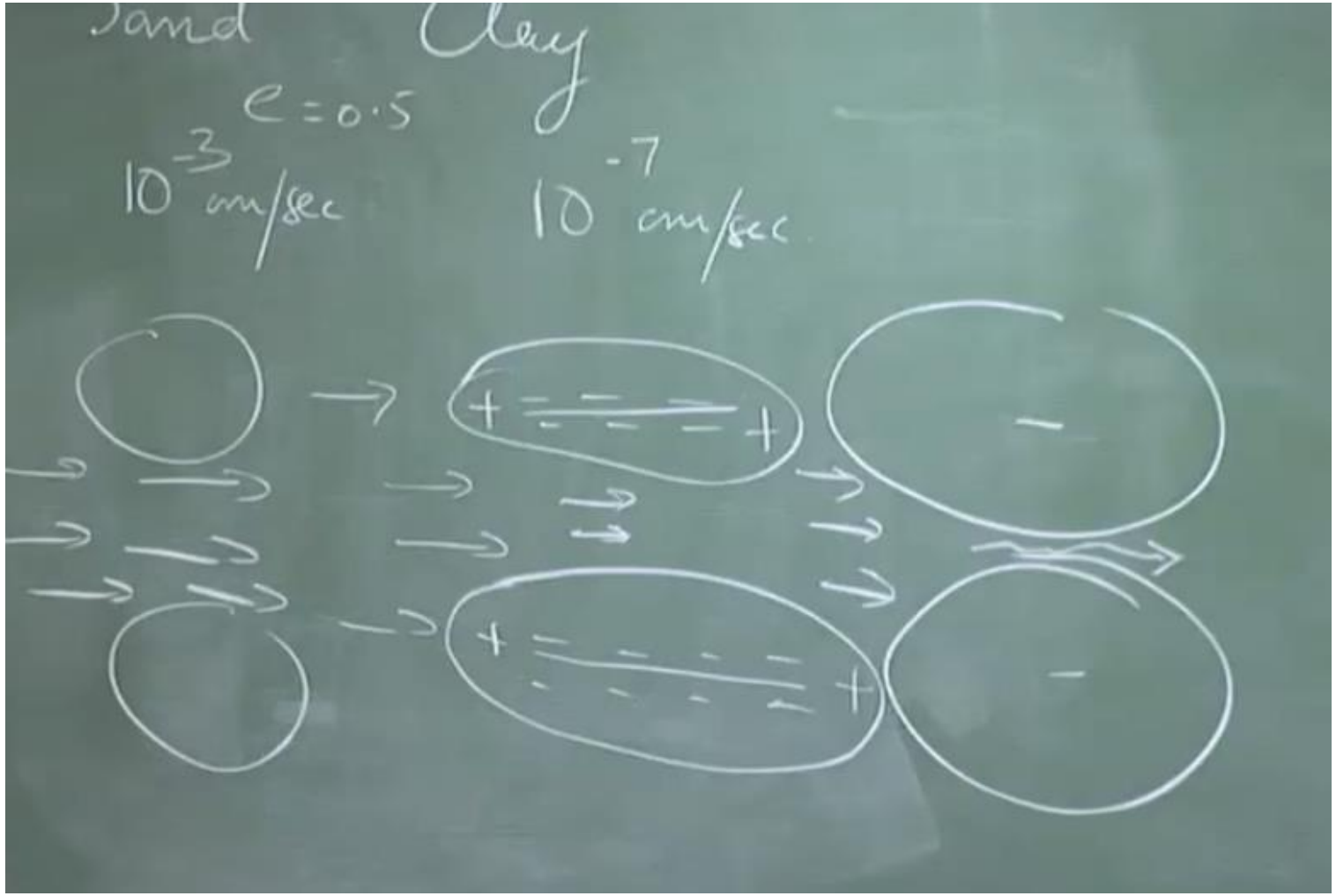



coated GCL, n - GCL product with at least one layer of a synthetic substance applied to the GCL as a fluid and allowed to solidify

# Typical Property of GCL – Geosynthetic Clay Liner

Enviromat® is a new generation geosynthetic clay liner (GCL) made from high quality polypropylene geotextiles and premium grade sodium bentonite. Enviromat® GCLs are fibre-reinforced by needle punching the composites across the entire surface area of the product. Sodium bentonite clay is a natural occurring clay mineral that swells when wet and hydrated. When this hydration occurs under confinement, the bentonite swells to form a low permeability clay layer that acts as a hydraulic barrier to fluids.

| Property | | Test Standard | Unit | Enviromat® 4000 | Enviromat® 5000 |
|---|---|---|---|---|---|
| **GCL mass components** | | | | | |
| Cover nonwoven mass | | ISO 9864 | $g/m^2$ | 180 | 180 |
| Bentonite mass | | ASTM D5993 | $g/m^2$ | 4000 | 5000 |
| Carrier PP woven mass | | ISO 9864 | $g/m^2$ | 150 | 200 |
| Total GCL mass | | ASTM D5993 | $g/m^2$ | 4330 | 5380 |
| **Bentonite properties** | | | | | |
| Swell index | | ASTM D5890 | mL/2g (min.) | 24 | 24 |
| Fluid loss | | ASTM D5891 | mL (max.) | 18 | 18 |
| **GCL properties** | | | | | |
| Grab strength | | ASTM D4632 | N | 400 | 450 |
| Tensile strength | MD | ISO 10319 | kN/m | 9 | 15 |
| Tensile strength | CD | ISO 10319 | kN/m | 6 | 8 |
| CBR puncture | | ISO 12236 | N | 1200 | 2000 |
| Peel strength | | ASTM D6496 | N/m | 360 | 360 |
| Hydrated shear strength | | ASTM D6243 (mod.) | kPa | 24 | 24 |
| Hydraulic conductivity | | ASTM D5887 | m/s | $5 \times 10^{-11}$ | $5 \times 10^{-11}$ |
| Index flux | | ASTM D5887 | $(m^3/m^2)/s$ | $1 \times 10^{-8}$ | $1 \times 10^{-8}$ |
| **Dimension** | | | | | |
| Width | | | m | 4.5 | 4.5 |
| Length | | | m | 30 | 30 |




Why Clay , not sand

# Permeability Values

**Permeability Values (m/sec) at e=0.5**

| | |
|---|---|
| Clean sand | ~$10^{-3}$ to $10^{-4}$ |
| Silts and silty sands | ~$10^{-6}$ to $10^{-9}$ |
| Silty clay, low plasticity | ~$10^{-9}$ |
| Clays, medium to high plasticity | ~$10^{-9}$ to $10^{-11}$ |
| Sand-silt-clay mixtures (no clods, low shrinkage) | ~$10^{-9}$ |

K of commercial bentonite: $10^{-9 \text{ to } -11}$ ; GM: < $10^{-13}$ cm/sec

# Permeability Requirements
# 滲透性要求

Permeability (hydraulic conductivity) less than $10^{-9}$ m/sec ($10^{-7}$ cm/sec)

滲透率（水力傳導率）小於 $10^{-9}$ 米/秒（$10^{-7}$ 厘米/秒）

At least 3 to 4 layers of compacted clay, each 0.2 to 0.25 m thick, properly bonded

至少 3 至 4 層壓實粘土，每層 0.2 至 0.25 米厚，適當粘合

No lumps or clods in compacted clay

壓實粘土中沒有結塊或土塊

No shrinkage or desiccation cracks (compact and cover)

無收縮或乾燥裂

Adequate strength

足夠的強度

No influence of leachate

無滲濾液影響

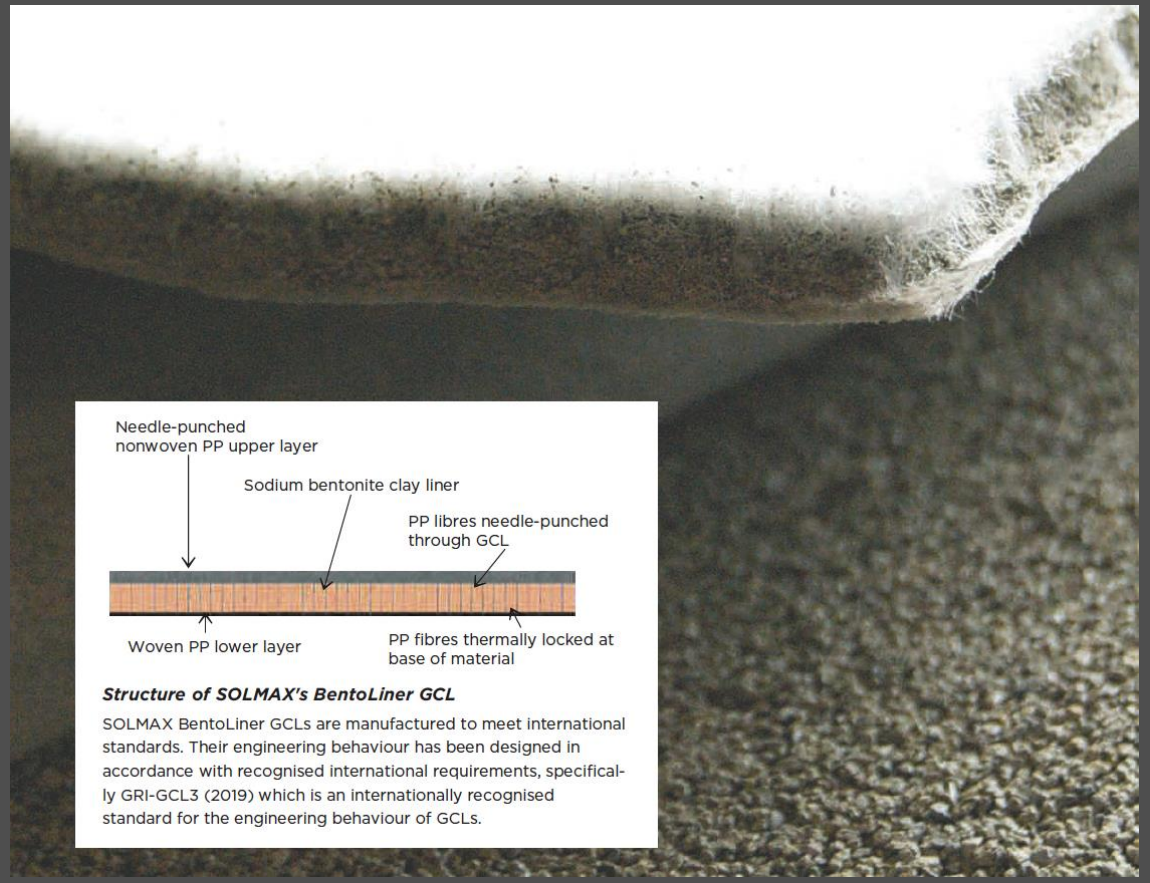
# Geosynthetic clay liner

- Barriers


GCL 1 – stitch-bonded

GCL 2 needle-punched

GCL 3 – needle-punched and thermal treated




***Structure of SOLMAX's BentoLiner GCL***

SOLMAX BentoLiner GCLs are manufactured to meet international standards. Their engineering behaviour has been designed in accordance with recognised international requirements, specifically GRI-GCL3 (2019) which is an internationally recognised standard for the engineering behaviour of GCLs.

## FABRIC-ENCASED GCL

BentoLiner fabric-encased geosynthetic clay liners have proven long term creep resistance and internal shear strength properties, which make them ideal for a wide range of containment lining and capping solutions.

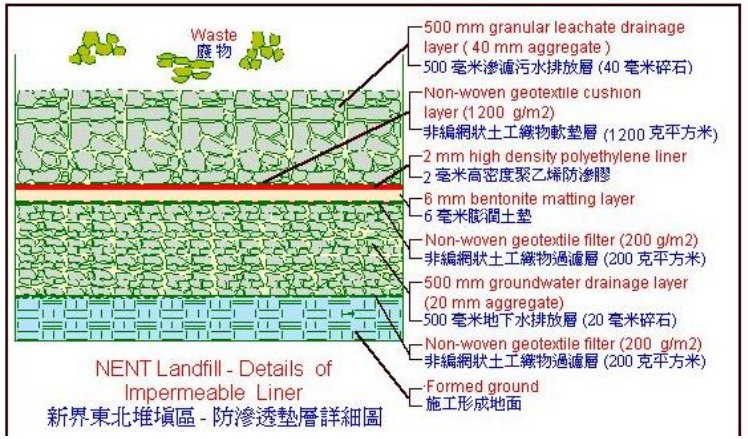
## GUNDSEAL®

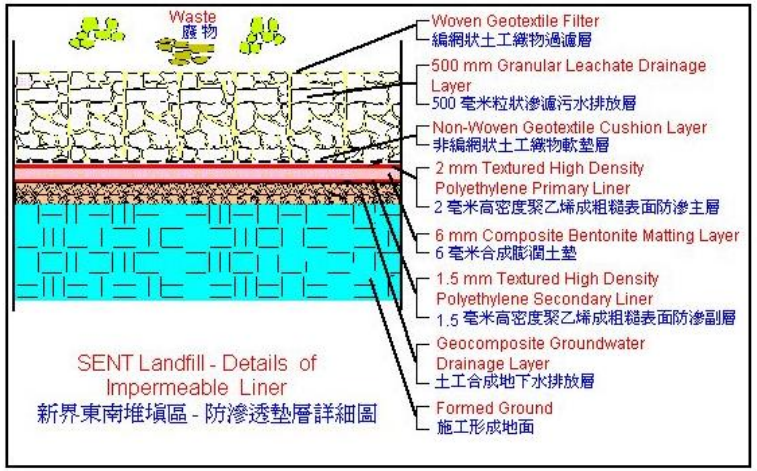
Gundseal® is a composite liner system consisting of sodium bentonite adhered to a polyethylene geomembrane. This acts as a barrier and provides the best leak protection for waste containment applications.

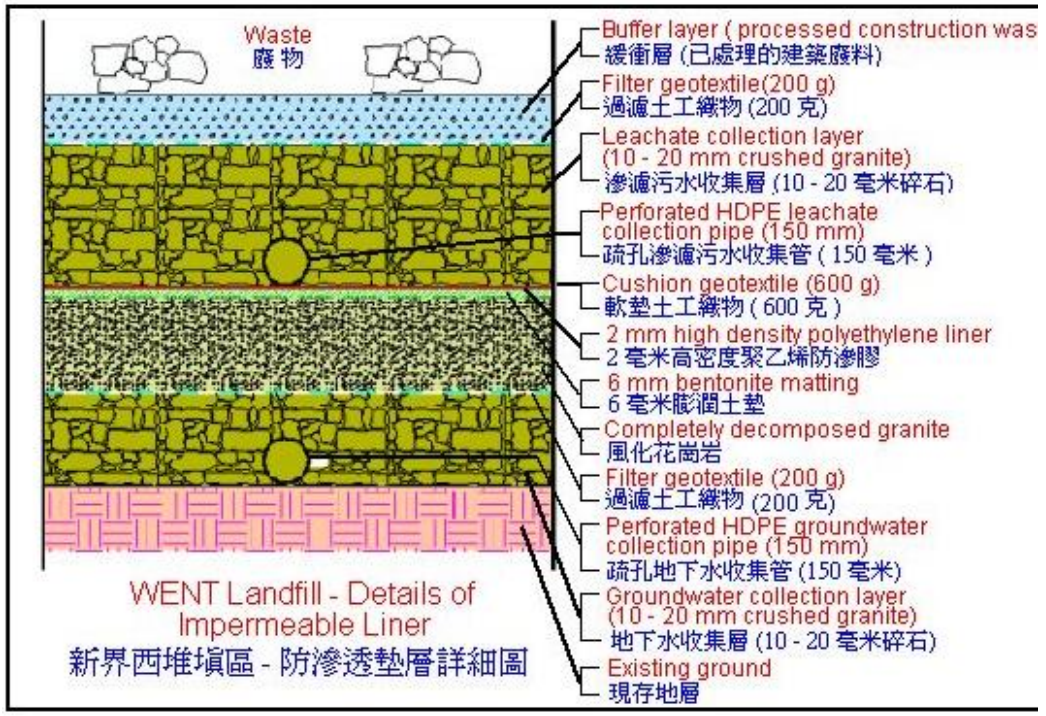
# Klung Landfill, Thailand

Polyfelt® Enviromat GCL used part of a double lining system of geosynthetic clay liner (GCL) and geomembrane (GM) to contain domestic and industrial waste leachate from contaminating groundwater.


# Hong Kong Landfill Design




Ref: HK WENT Landfill Liner System

TENCATE Geotube®

# TECHNICAL DATA

| | | |
|---|---|---|
| Date of issue: | 01 September 2021 | |
| Project name: | Contract 3310 North Runway Modification Works | |
| **Product name:** | **Silt Curtain SC150** | |
| Manufacturer: | TenCate Geosynthetics Asia Sdn. Bhd. | |
| Character of the geotextile: | High tenacity engineering woven geotextiles | |
| Mechanical characteristics: | Tolerance range<br>Confidence level | = -10% of average (min value)<br>= 95% |
| Hydraulic characteristics: | Tolerance range<br>Confidence level | = -30% of average (min value)<br>= 95% |

**Mechanical characteristics**

| | | | |
|---|---|---|---|
| Characteristic short term tensile strength (md) | (kN/m) | 150 | ISO 10319 |
| Characteristic short term tensile strength (cd) | (kN/m) | 150 | ISO 10319 |
| Strain at short term tensile strength (md) | (%) | <20 | ISO 10319 |
| Strain at short term tensile strength (cd) | (%) | <20 | ISO 10319 |

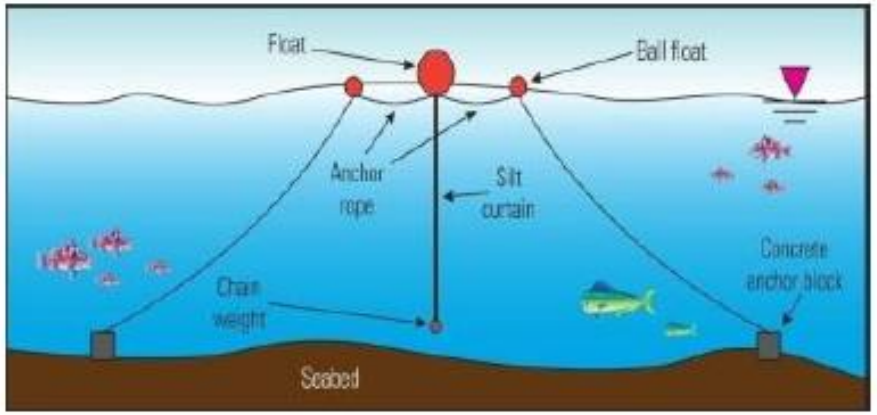
**Hydraulic characteristics**

| | | | |
|---|---|---|---|
| Opening size $O_{90}$ | (mm) | <0.25 | ISO 12956 |
| Water flow @ 50mm head | ($l/m^2/min$) | 60 | ISO 11058 |

# Typical Technical Data for Silt Curtain

# Jimah Power Plant Reclamation, Malaysia

Geotube® SC silt curtain used for turbidity control during the land reclamation works.




e, effective containment of silt coming from outfall

fective containment of the silt within the work area

# Silt Curtain Operation Photos

# TKO Silt Curtain Application

# Do not Mix Up Your Submission Material

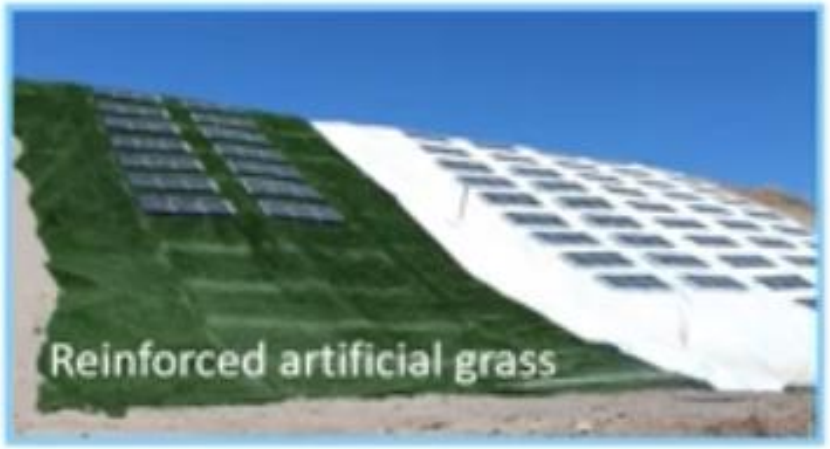
**3.0 Use of Material**

Mirafi PET 100-100 Series Woven Geotextile which manufactured by TenCate Industrials Zhuhai Co., Ltd which is proposed in the silt curtain system of the captioned project, catalogue is attached in ***Appendix E***. The Bontec SG110/110 geotextile is widely used in recent marine works construction site. The properties of the proposed geotextile are satisfactory and fulfill the requirement as stipulated in particular specification. Visual inspection of the silt screen shall be carried in a daily basis.

According to the Environmental Monitoring and Auditing (EM&A) Manual, regularly water monitoring of water quality shall be carried out by Environmental Team (ET) in order to complies statutory regulation and maintain quality of water during the construction activities being undertaken.

# Speciality products



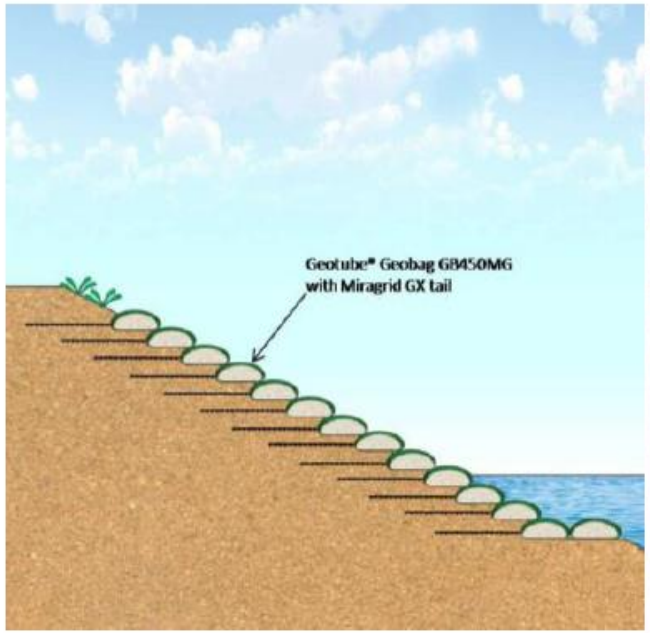




ARTICLE
Inside Waste - Solar Energy Landfill Cover Systems

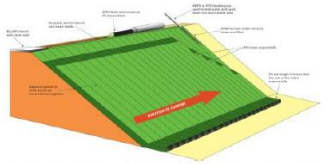
## Sungkai River Bank Erosion Protection, Malaysia

A water treatment plant along Sungkai River requires erosion protection.
Geotube® GB450MG geobags with geogrid reinforcement tail used as riverbank erosion protection units.




## Chaung Ma Irrigation Canal, Myanmar

Geotube® SFM1000G geomattress filled with sand was used to line the irrigation canal section for erosion protection of the canals.



## Sinthay River Valley Irrigation, Myanmar

1.5 km of irrigation canals were constructed to allow all year round multiple crop cultivation to be carried out.

Geotube® CFM geomattress filled with micro-concrete was used for erosion protection of the newly constructed irrigation canals.

# Geosynthetic Benefits

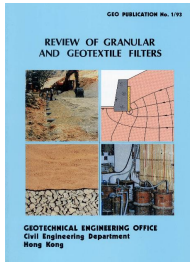
- Ecological : Significantly lower carbon footprint for construction
- 生態：顯著降低建築的碳足跡
- Safety : Protects vital resources
- 安全：保護重要資源 經濟性：更高效的施工、更長的使用壽命、更少的維護
- Economics : More efficient construction, longer service lives, less maintenance
- 經濟性：更高效的施工、更長的使用壽命、更少的維護
- Comport : Easy to handle and install
- 舒適：易於操作和安裝
- Reliable : Far over half of a century of projects and innovations
- 可靠：半個多世紀以來的項目和創新
- Resilience : Enhanced performance (ability to respond, absorb, and adapt to, as well as recover in a disruptive event)
- 彈性：增強的性能

# Quality Control is Crucial

## 13.2 QUALITY CONTROL PROCEDURES DURING CONSTRUCTION

Manufacturers' certificates provided for geotextiles used as permanent filters should include information on the date and place of manufacture, constituent polymers and additives, geotextile construction, and the results of relevant tests of the hydraulic and mechanical properties. The information should be checked with specifications for non-compliance.

For slopes and retaining walls belonging to the high risk category, compliance tests on geotextile samples selected by the engineer should be carried out during construction. In particular, the mass per unit area, tensile properties (tensile strength and elongation at failure) and hydraulic properties (opening size and water permeability) of selected samples should be determined and checked against the requirements of the specification.



# Summary

Geosynthetics are divided into two main characteristics : Permeable and Impermeable

Geosynthetics分為兩個主要特性：透水性和不透水性

Geosynthetics are used to fulfil hydraulically and / or mechanical functions

Geosynthetics用於實現水力和/或機械功能

Geosynthetics can fulfil one or more functions at the same time

Geosynthetics可以同時實現一種或多種功能

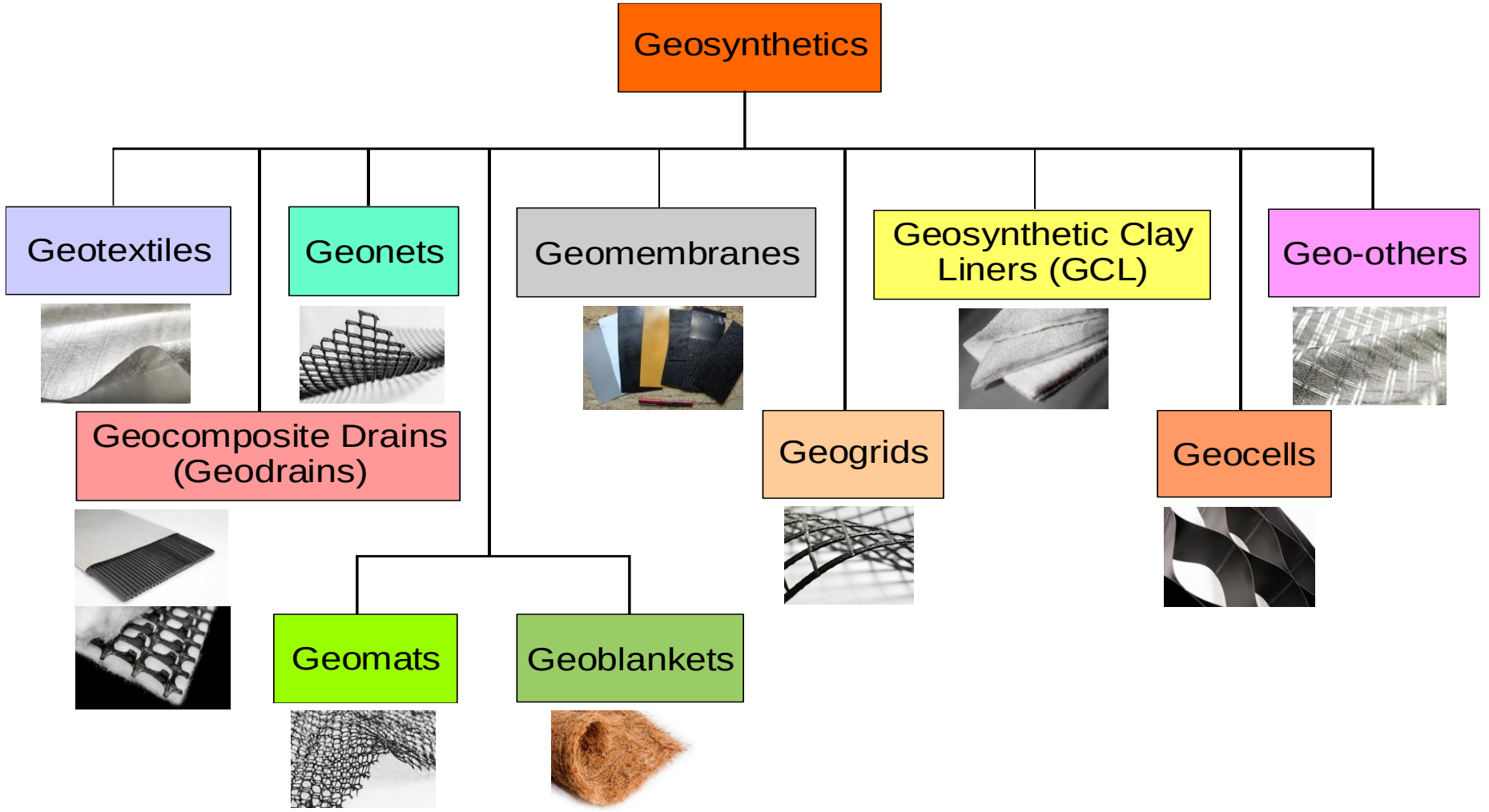
Different products fulfil different functions

不同的產品實現不同的功能

Geosynthetics offer add-on benefits

Geosynthetics具有附加優勢

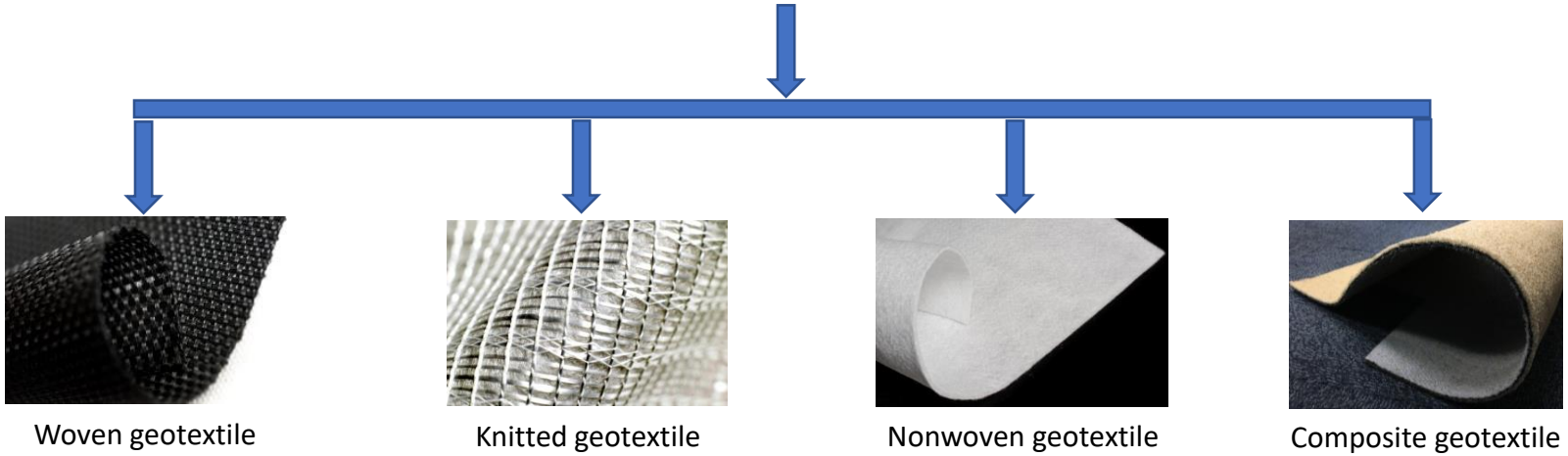
# Can you name the Classification of Geosynthetics ?



*GEOTEXTILES* can be simply defined as

*TEXTILES* used for

*GEO-TECHNICAL, GEO-HYDRAULIC & GEO-ENVIRONMENTAL* applications




Base material often referred to in manufacture. eg. PE, PP, PET, Nylon, Kevlar, coir, etc.

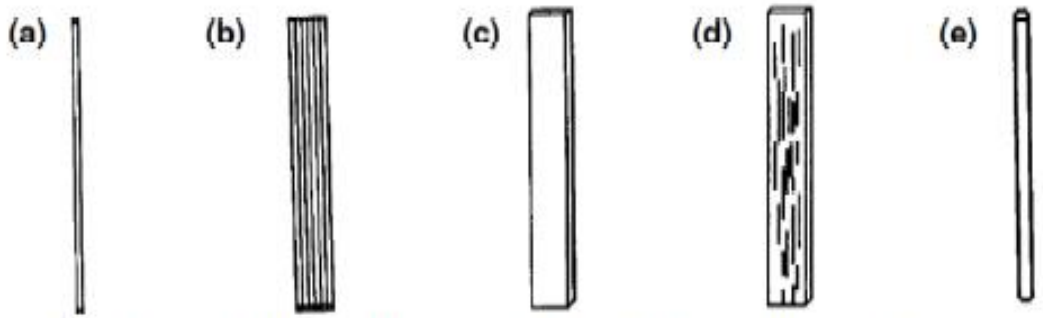



Figure 2. Types of fibers and yarns typically used for manufacture of geotextiles (a) filament yarn (b) multifilament yarn (c) slit tape yarn (d) fibrillated yarn (e) monofilament yarn (adapted from Bhatia and Smith 1996)


Figure 3. Types of geotextiles (a) needlepunched nonwoven (a) heatbonded nonwoven (c) woven multifilament (d) woven slit tape (e) woven monofilament (adapted from Bhatia and Smith 1996; Aydilek and Edil 2002)

# You Want Left, or Right ?

Short Fiber or Stable Fiber

Coconut Fiber

# You Want Left, or Right ?

# Engineering Problem

## Low bearing capacity subgrades


# Engineering Problem

## Weak and compressible foundation soils

# 「深層水泥拌合法」第二次實地測試