COLETANCHE®

2025/01

DESIGN & APPLICATION HANDBOOK

ENVIRONMENT • HYDRAULIC • UNDERGROUND WORKS • TRANSPORT


COLETANCHE®

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1. GENERAL COMPANY INFORMATION

1.1. COMPANY

1.1.1. IKO-AXTER GROUP

IKO is a key player in waterproofing systems, working with determination to offer high-quality products: reliable, durable and well-known for their technical expertise.

The IKO Group focuses on customer satisfaction every step of the way, offering high value-added services: product advice, support from A to Z... all made possible by the commitment and dedication of its 300 employees.

With a legacy of over 150 years, IKO places innovation and the design of eco-responsible solutions at the heart of its approach and seeks to effectively combine sustainability and performance.

We are proud to be a trusted partner to professionals in the construction industry, ready to meet the challenges and work together to create an environmentally friendly future.

In 2021, Axter joined the IKO group to expand its waterproofing activities. Axter designs, manufactures and distributes bituminous waterproofing membranes for flat roofs and geomembranes for civil engineering works with its dedicated brand Coletanche.

More than 50% of Axter's waterproofing membrane production is for its export markets in 70 countries all around the world (Europe, Africa, the Middle East, North and South America, Asia and Pacific area).

Axter's manufacturing plant is based at the industrial site of Courchelettes, in northern France, with:

- 3 production lines for bituminous roofing membranes;
- 1 production line for Coletanche.

1.1.2. COLETANCHE, DEDICATED TO CIVIL ENGINEERING PROJECTS

With its Coletanche brand, AXTER offers a range of geomembrane construction solutions for public works and civil engineering projects around the world. The high technical performance of these solutions makes them suitable for a wide range of applications for both new build and renovation projects in various sectors:

- Environment: retention of solid and liquid waste, biogas barriers, etc.
- Hydraulics: dams, canals, basins, etc.
- Transport: bridges, roadside ditches, railway lines, etc.
- Underground construction: buried walls, waterproof linings, underground structures, tunnels, etc.

Coletanche is a bituminous geomembrane waterproofing system, unique in terms of its 5.10m width. Coletanche geomembrane combines an elastomeric bitumen based binder and an internal structure made from non-woven polyester geotextile; it is designed to guarantee excellent mechanical and chemical resistance over the long term.

1.1.3. FACTORY HISTORY

70's
In-situ Coletanche: introduction of a new bituminous waterproofing solution by Colas and Shell. Coletanche is made by impregnating - manually or by a distributor truck - an in-situ geotextile with hot bitumen.

1974
Factory established to prefabricate bitumen impregnated geotextile material, Coletanche NTP (oxidized bitumen) in France improving the quality control of the finished product. The product width is 4 meters.

1986
First production of Coletanche ES grade with elastomeric bitumen.

2000
Creation of a new dedicated production unit for Coletanche in Galway, Ireland. The width of Coletanche was increasedh to 5.1 meters with a production capacity of 1 million m^2

2007
The Coletanche production line moved to Courchelettes, France in IKO-Axter's facility. The aim was to improve the production quality and benefit fromthe expertise of an international waterproofing group. Production capacity increased to 3 million of m^2

2009
Creation of the Canadian subsidiary.

1.1.4. HISTORICAL REFERENCES

1973
First Coletanche project as an in-situ bitumen waterproofing solution in Castelet, on Grand Prix de France F1 car circuit. Construction of ponds.

1976
First projects waterproofed with Coletanche NTP: dams, ponds and liquid waste storage.

1978
First canal waterproofed with Coletanche NTP. La Courneuve, France project: first project with more than 100 000m^2 installed.

1979
First landfill and road transportation projects waterproofed with Coletanche NTP.

1981
First project abroad in Niger.

1983
First railway projects with SNCF company.

1986
First waterproofing project with Coletanche ES - 15000m^2.

2001
Kildare bypass project in Ireland on motorway M7: first project with more than 200 000m^2 of Coletanche installed.

2020
Launch of Coletanche Solar, an innovative solution that generates electric power through the combination of flexible photovoltaic modules with the bituminous geomembrane. This solution adds value to previously unused industrial or mining waste areas.

2014
Improvement of the production line by adding a finished product accumulator. Production capacity increased to 3.5 million of m^2.

2018
First production of XP grade using a single reinforcement system.

2017
Improvement of the heart of the production line to increase the quality of the finished product and allow the use of new types of reinforcement. Production capacity increased to 6 million of m^2.

2019
Creation of a subsidiary in Australia – Axter Australia Pty Ltd.

2021
AXTER SAS purchased by Canadian group IKO
Incorporation of a subsidiary in Chile – IKO Coletanche Sudamérica SpA..

2007
Beginning of a gold mine project in Northern Europe. To date, 1.5 million m^2 has already been installed.

2011
Ditches for French Highway 63 using a new product with specific performance requirements, Coletanche SC.

2003
First project in Canada.

2018
First projects using new grade Coletanche XP.

2006
Tailings dam in a gold mine in Kupol Siberia by a temperature of -45°C.

2010
First work for US Navy with approval of US Corps of Engineers. Capping wastes in US Navy base of Motco near Oakland (California).

2015
First project in Australia: capping of a mine.

List of projects is available upon request.

2. FOREWORD

2.1. HANDBOOK PURPOSE

The purpose of this handbook is to provide all information relevant to the Coletanche development and to ensure that all designers familiarize themselves with this product, its application and operational conditions.

The term geomembrane refers to all membrane barriers intended for civil engineering structures. Geomembranes are thin, flexible, seamless, and impermeable in all circumstances, according to Darcy's Law (coefficient of permeability below 10^{-13} m/s), and retain their properties even when in service.

Based on current techniques, products thinner than 1 mm (40 mils), commonly called films are not considered to be geomembranes.

This handbook provides all the information needed to complete a project using a Coletanche geomembrane, from worksite planning to preparation to project completion and inspection.

This document includes several pictures taken from projects performed over the past 40 years.

2.2. USERS

This handbook is mainly intended for all people involved in a project:

For research offices

- Design;
- Operations;
- Operation managers;
- Work supervisors;
- Foremen.

For the departments

- Internal Control;
- External Control.

This handbook may not be distributed to competition.

The general recommendations provided in this handbook apply mainly to the following fields:

Environment

- Solid waste storage*;
- Domestic waste containment;
- Industrial or mining waste covering;
- Polluted snow storage area;
- Compost area, clinkers containment pad and other wastes;
- Liquid waste storage*;
- Tailings pond;
- Decantation Dam for polluted water;
- Decantation Pond for polluted water;
- Secondary containment;
- Protection against agricultural pollution;
- Biogas barrier*;
- Construction of industrial, commercial and housing buildings in a polluted area;
- Heap Leach Pads.

Hydraulic

- Dams*;
- Channels*;
- Irrigation canals;
- Shipping canals;
- Reservoirs and basins*;
- Banks protection.

Transportation

- Railroads*;
- Roads and airports;
- Protection of aquifers;
- Ditches*;
- Stormwater pond;
- Underground structures*;
- Tunnels.

This list is non-exhaustive. Bridge and building (roofs and decks) waterproofing is not covered in this handbook.

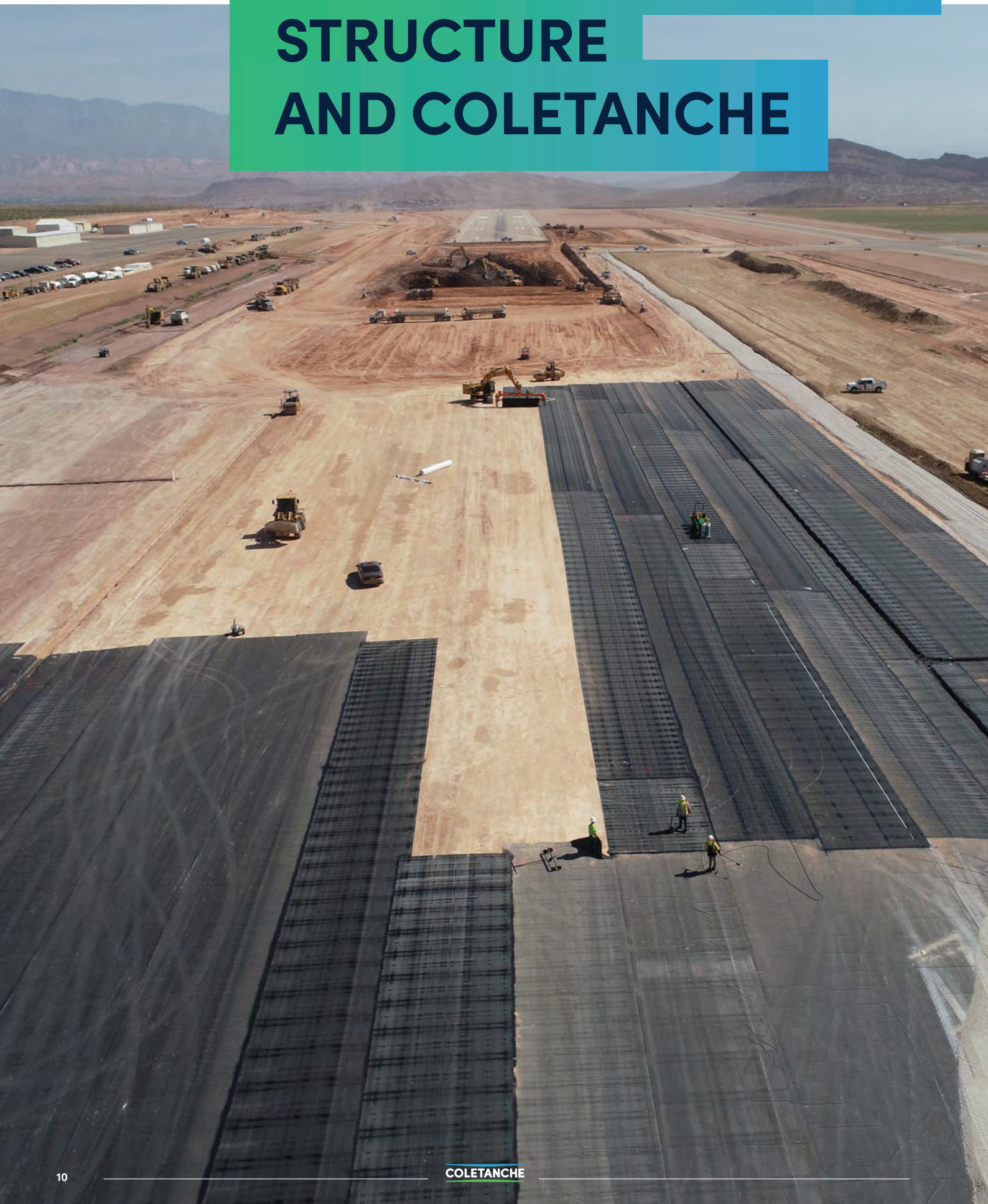
2.3. CUSTOMER TECHNICAL ASSISTANCE

Coletanche can supply the necessary technical assistance:

- Either for the design suggestions, or to prepare alternate proposal to another geomembrane;
- Training new staff in installation and quality control.

**brochure available, ask your local representative to receive it*

3. USING A WATERPROOF STRUCTURE AND COLETANCHE



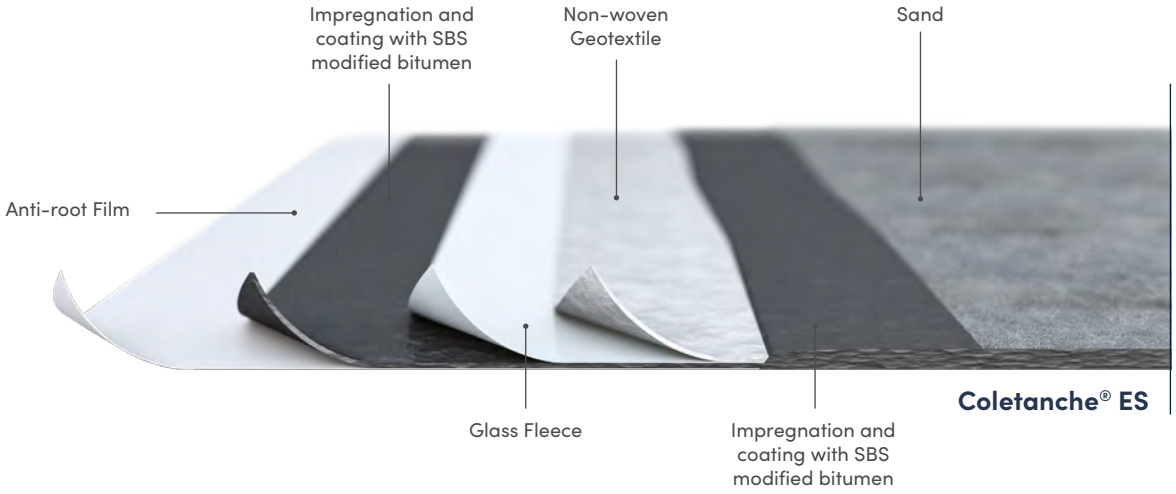
The purpose of this chapter is to help engineering departments and firms which are designing projects incorporating a waterproofing structure. It presents the notion of geomembrane waterproofing systems and the methods in which they are used.

3.1. COLETANCHE STRUCTURE

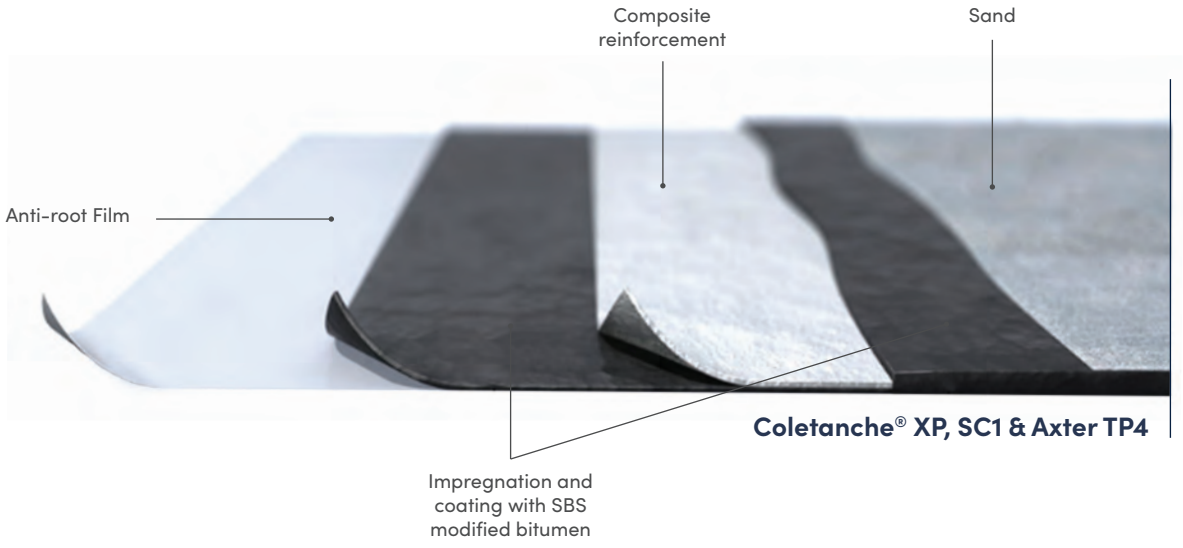
Coletanche is a combination of a non-woven polyester geotextile for mechanical resistance, and a specifically designed bituminous binder that guarantees waterproofing, chemical resistance and ageing behavior.

There are two ranges of product:

- **Coletanche® ES** range which is a double reinforcement system with a long-fiber non-woven polyester geotextile associated with a glass fleece.



- **Coletanche® XP, SC1 & Axter TP4** ranges which are single reinforcement products consisting of a stabilized polyester geotextile.



Regular grades of Coletanche® ES and XP ranges have a sanded upper surface and a smooth underside coated with a terphane film.

For all our products, a High Friction Angle (HFA) grade can be offered to achieve a similar angle of friction on both sides of the geomembrane. In this case, the upper side remains sanded, but the underside is replaced by a release plastic film. This film is removed during placement of the geomembrane.

Coletanche® ES

ANTI-PERFORATION FILM

PEELABLE PE SILICONE FILM

Coletanche® ES HFA

3.1.1. PHYSICAL PROPERTIES

At lower thickness, a single reinforcement product (XP range) can have a binder amount equal to or greater than a dual reinforcement product (ES range).

> *For more detailed information on these physical properties, please visit our website or contact your Coletanche representative.*

IMPORTANT NOTE: most of the rolls are made of one single piece. However due to manufacturing constraints, some rolls may have a transversal cut (typically no more than 30% of the delivered rolls). This is highlighted by a yellow tape and length of each piece is indicated on the roll identification label.

3.1.2. MECHANICAL PROPERTIES

The types and different weights of the Coletanche geotextiles affect the thickness and mechanical performance of the geomembrane. A thinner geomembrane may have a mechanical performance equal to or greater than that of a geomembrane of greater thickness.

> *For more detailed information on these mechanical properties, please visit our website or contact your Coletanche representative.*

3.1.3. WATERPROOFING AND GAS PERMEABILITY

Standard CE & ASTM	WATER AND GAS (METHANE) PERMEABILITY: RESULTS OF EXTERNAL CONTROLS*												
	Standard	Unit	ES1	ES2	ES3	ES4	SC1	XPC	XP1	XP2	XP3	XP4	AXTER TP4
Water permeability	EN 14150	$m^3/m^2/d$	$\leq 1.10^{-6}$				$\leq 1.10^{-6}$	$\leq 1.10^{-6}$					$\leq 1.10^{-6}$
	ASTM E96	m/s	$\leq 6.10^{-14}$				$\leq 6.10^{-14}$	$\leq 6.10^{-14}$					$\leq 6.10^{-14}$
Gas permeability	ASTM D1434-82	$m^3/(m^2.d.atm)$	$\leq 2.10^{-4}$				$\leq 2.10^{-4}$	$\leq 2.10^{-4}$					$\leq 2.10^{-4}$

** Values reported based on the performance of the minimum thickness.*

NOTE: in general, increasing the thickness of the geomembrane reduces gas permeability.

In view of the pace of change in science and technology, the information in these tables can change. Those pages are intended to give key numbers and a sense of proportion of Coletanche solutions. Please check with our team if you need more specific numbers.

FRICTION ANGLE

The table below presents the results of a sliding angle measurement study φ' of different materials (natural or geosynthetic) placed in contact with the smooth or sanded side of a Coletanche bituminous geomembrane.

Tested side of the bituminous membrane	Material in contact with the bituminous plate	Angle φ' (°)
Smooth	Crushed gravel 0/31.5	33
	Sand 0/5	25
	Geotextile 011/400	21
	HMA plate	36
Sanded	Crushed gravel 0/31.5	38
	Geotextile 011/400	32
	ENKADRAIN E8004H/5-1s/D110P.	36
	ENKAMAT 7010W/5/H20.20.PET	30
	ENKAMAT 7010W/5/N.80.80.PP	27
	Topsoil 1 (sandy)	36
	Topsoil 2 (clay)	36
	In situ cast concrete: test after 15 min.	36
	In situ cast concrete: test after 8 days.	>45

Lyon INSA study, 2002, according to the NFP 84-522 standard.

NOTE: with special manufacturing, it is possible to obtain the same coefficient of friction of the sanded side on both sides of the geomembrane. This "High Friction Angle" option is available for all ranges, please contact us.

3.1.4. CHEMICAL, BIOLOGICAL, AND RODENT RESISTANCE

CHEMICAL RESISTANCE

Coletanche geomembranes contain elastomeric bitumen with good resistance to chemical products with a pH between 2 and 13. Contact the Coletanche technical service with information on the PH, concentration and temperature of your solution to verify compatibility.

Advantages

The following advantages were noticed through resistance studies regarding the pH, chemical composition, temperature and concentration:

- Longevity;
- High mechanical resistance;
- Very weak thermal dilation remains permanently in contact with the support layer;
- Bitumen is visco-elastic;
- Installation at very low temperatures of -35 °C;
- Because of its robustness and of its weight, no holes are easily created during the installation, Coletanche provides a better resistance against wind;
- Coletanche is perfectly adapted for in-ground civil engineering structures because it adapts to differential ground compaction and deformation.

Our technical service can tell you whether Coletanche is appropriate for your project and whether any special precautions are required. For example, applying Coletanche upside down (i.e., with terphane film in contact with the effluent) may be a good solution in some cases.

BIOLOGICAL RESISTANCE

Bacterial resistance

The conservation of pre-biblical remains is a testimony of the durability and longevity of bitumen and an indication of its excellent resistance.

Since the Neolithic, bitumen served to waterproof containers (baskets, earthenware jars, storage pits), wooden posts, palace grounds (e.g. in Mari and Haradum), reserves of lustral waters, bathrooms, palm roofs, etc. Mats, sarcophagi, coffins, and jars, used for funeral practices, were often covered, and sealed with bitumen.[1]

▲ Reconstruction of the hull of a boat from the Bronze Age coated with bitumen.

Photo credit: NYU Abu Dahbi

Microbial resistance

Microbial action on bitumen is so slow that, for all intents and purposes, bitumen is considered immune to microbial attack.

References: The Shell Bitumen Industrial Handbook, and the US Atomic Energy Agency of Hanford (State of Washington, USA).

Rodent and insect resistance

Insect, rat, and small animal resistance was studied in detail by Nicolle and Pankhust – *Bitumen Versus Coal Tar: Biological Aspects,* University of Kent at Canterbury, UK), as well as by the *Laboratoire d'Hygiène de la Ville de Paris* (France).

They showed that even starving rats did not attack bitumen. Other studies in Europe and Australia showed that bitumen-impregnated materials are not attacked by rats, muskrats, termites, beetles, cockroaches, or kangaroos.

Root penetration

The terphane film prevents root penetration of the bitumen geomembrane.

3.1.5. CHOICE OF GEOMEMBRANE

Given the diversity of subgrades, nature of protection and operating conditions, there is no definitive design guide for selecting the type of Coletanche.

The performances of each Coletanche grade nonetheless help specify:

Coletanche XPC	Coletanche ES1 / XP1 / XP2	Coletanche ES2 / XP2 / XP3 / AXTER TP	Coletanche ES3 / XP3 / XP4	Coletanche ES4 / XP4
Very low mechanical constraints ▸ Vegetated drainage channels	**Low mechanical constraints** ▸ Installation cover for waste, stockpiles	**Medium mechanical constraints (compatible with asphalt protection)** ▸ Hydraulic, mining, and industrial basins ▸ Industrial areas ▸ Biogas barrier ▸ Methanisation platforms	**Severe mechanical constraints, puncture materials, thick layers, significant stress** ▸ Dams ▸ Deep hydraulic basins ▸ Industrial waste storage areas ▸ Landfill bases for waste storage facilities	**Extreme mechanical constraints, aggressive materials, reinforced precautions** ▸ Railways, use under ballast ▸ Containment of hazardous waste ▸ High dams

1- Connan J. Use and trade of bitumen in antiquity and prehistory: molecular archaeology reveals secrets of past civilizations. Philos Trans R Soc Lond B Biol Sci. 1999 Jan 29;354(1379):33–50. doi: 10.1098/rstb.1999.0358. PMCID: PMC1692448.

3.2. CHOICE OF WATERPROOF STRUCTURE

3.2.1. CONCEPT

Waterproofing is a global notion that cannot be limited to the simple choice of a geomembrane.
This is the reason why it is referred to a "Geomembrane Waterproofing System", which includes from top to bottom:

- Below the geomembrane:
  - A mechanical protection layer;
  - A rainwater drainage device over solid waste or leachates at the bottom of discharges;
- Waterproofing structure:
  - The geomembrane itself;
- Support structure:
  - A gas drainage layer;
  - A water drainage layer if the presence of water is envisaged (water table, springs, inlets);
  - A passive barrier or subgrade (support).

3.2.2. GEOMEMBRANE WATERPROOF STRUCTURE

The following definitions are taken from the French standard NFP 84-500 (2013).

GEOMEMBRANE WATERPROOF STRUCTURE

PROTECTIVE STRUCTURE (OPTIONAL)

- Protective structure: Materials placed on top of the geomembrane

- Granular material
- Topsoil
- Watertight bituminous concrete

WATERPROOFING STRUCTURE

- Waterproofing structure: Waterproofing assembly composed of a geomembrane

- Geomembrane: A product designed for civil engineering applications that is thin, flexible, continuous, and watertight even when stressed (primarily tensile strain) in service

Note 1: According to current technical standards, geomembranes less than 1 mm thick, less than 1.5 meters wide, or whose sealing capacity depends solely on clay material (e.g., BCL, bentonic clay liner) are not considered geomembranes.

SUPPORTING STRUCTURE (IF USED)

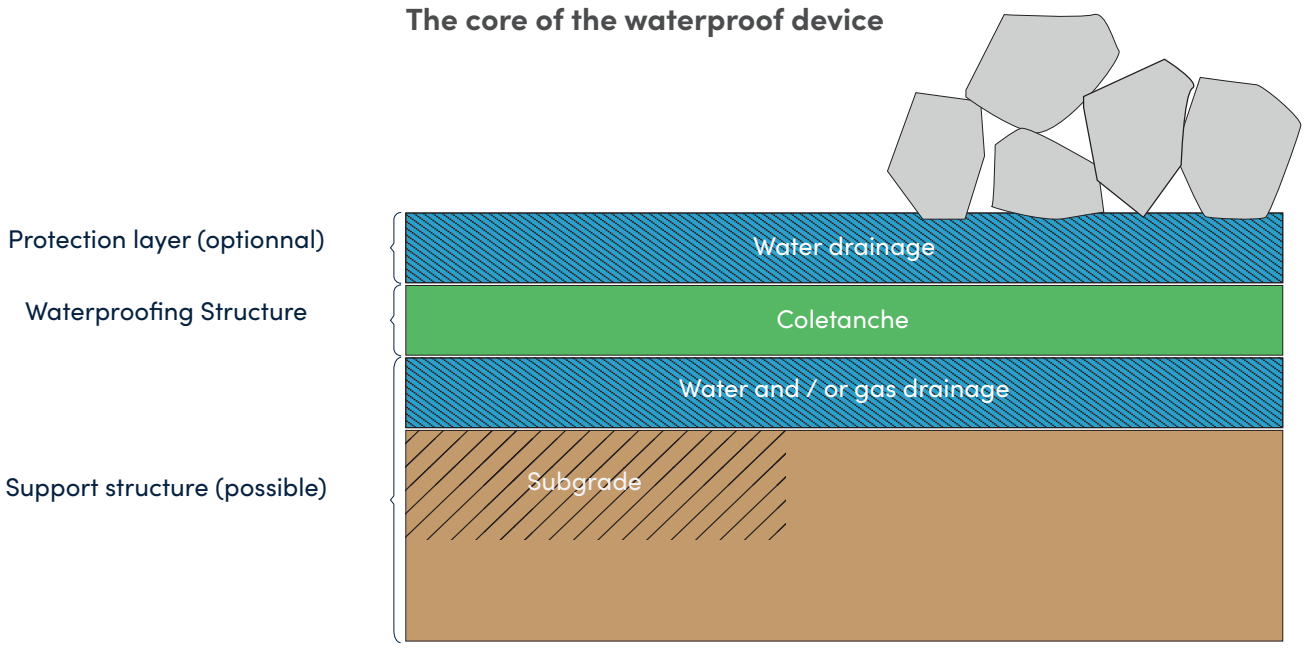
- Supporting structure: Materials placed between the subgrade and the geomembrane:
  - Subgrade
  - Base
  - Drain blanket* (water and gas)

Note: One or more elements may not be present, or may be found in the same layer.

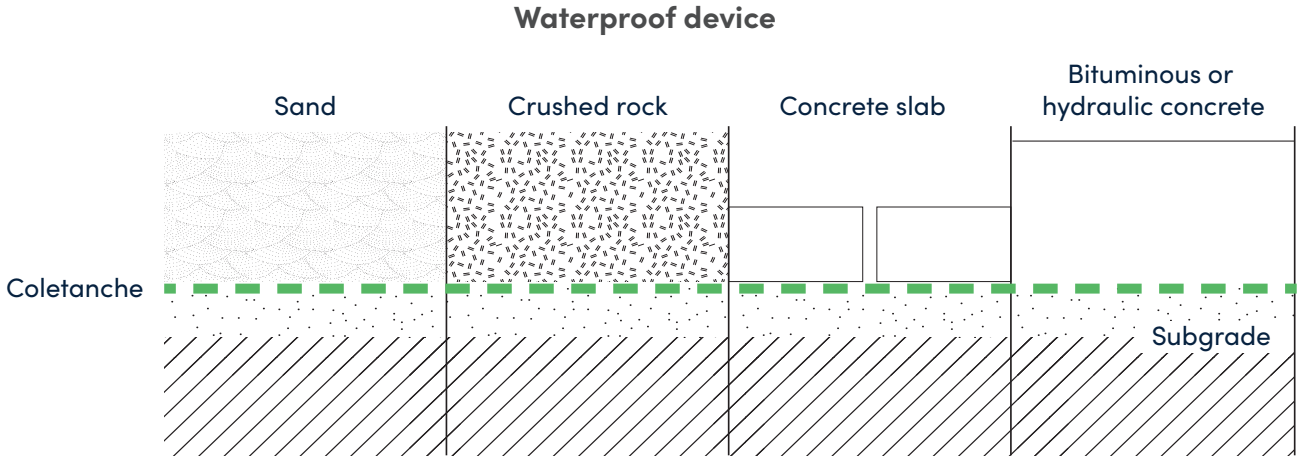
- Supporting layer: Layer of the supporting structure on which the geomembrane and granular base (without geotextile) rest

- Subgrade: Layer of the supporting structure that rests on the base

** This is also called the "levelling course."*



Example of lining system under a granular material



3.2.3. EMBANKMENTS

Project design and embankment work are based on the Quebec Department of Transport document, *Recommandation pour les terrassements routiers (Recommendations for Highway Embankments),* and also on the *Association des constructeurs de routes et grands travaux du Québec (ACRGTQ).*

Projects must also take into consideration the limitations on the use of waterproofing geomembranes caused by the nature of the terrain and the geometry of the structure or works.

Projects must be preceded by geological and geotechnical site studies.

For structures on former construction debris recovery areas (aggregate, broken ashlars, etc.) that have been backfilled, special precautions must be taken to locate cavities and sinkholes that could cause subsidence when water flows under the geomembrane (infiltration from the slope) or that could collapse under the water pressure.

3.2.4. BERMS

The slopes of berms, when equal or above 8 m, must always be less than 1H/1V for the following reasons:

- The geomembrane will stay in place under its own weight for long periods (no slipping or flowing);
- There is much less risk of the geomembrane sliding down the slope when a highly variable stress is applied such as emptying of filling a reservoir;
- Work is easier;
- These indications do not take into account limitations caused by the drainage or recovery layer, which will be discussed later.

NOTE: One can install on slopes higher than 1H/1V on approval of the representative.

3.2.5. SUBGRADE PREPARATION

Once the project requirements have been met, the subgrade must be inspected to ensure there are no sharp-edged aggregates (flint, for example).

If there are, the support must be compacted or, if this is insufficient, the surface must be re-graded using a shallow layer of sand or a non-woven geotextile. This last solution is generally preferable, on steep slopes in which creep exacerbates the effects of problematic subgrades.

After compaction, the ground can be sterilized where plant growth could cause problems, especially near anchorages.

Read more on this topic in section 4.4.

3.2.6. GEOTEXTILES

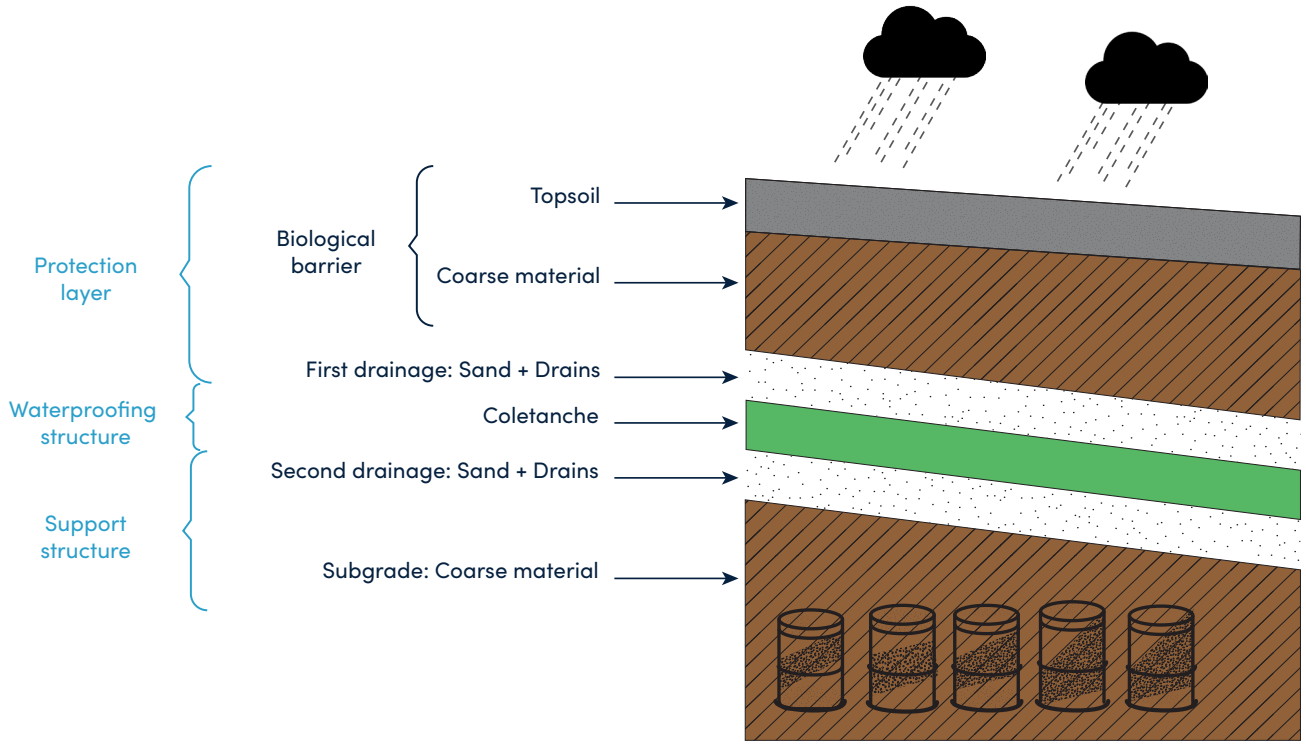
Synthetic geomembranes such as HDPE or PVC generally require 2 protection geotextiles, in order to create a complex structure that will guarantee the waterproofing behavior together with the mechanical resistance, and prevent puncturing in the long term.

Taking into account its structure which already includes a geotextile, a waterproofing structure based upon Coletanche generally avoids the need for external geotextiles of protection.

The Coletanche family includes a wide range of thicknesses. It is generally advisable to use a higher grade of Coletanche, instead of laying a thinner product plus a geotextile, as this would lead to extra operations on complex sites, especially in windy regions.

Also, when Coletanche is in direct contact with the subgrade, and particularly clayey soils, it is a safer solution than adding a geotextile layer, which might create a preferential path for water flow in case of leakage. Coletanche acts as a composite barrier.

Typical Coletanche cross-section (composite barrier)



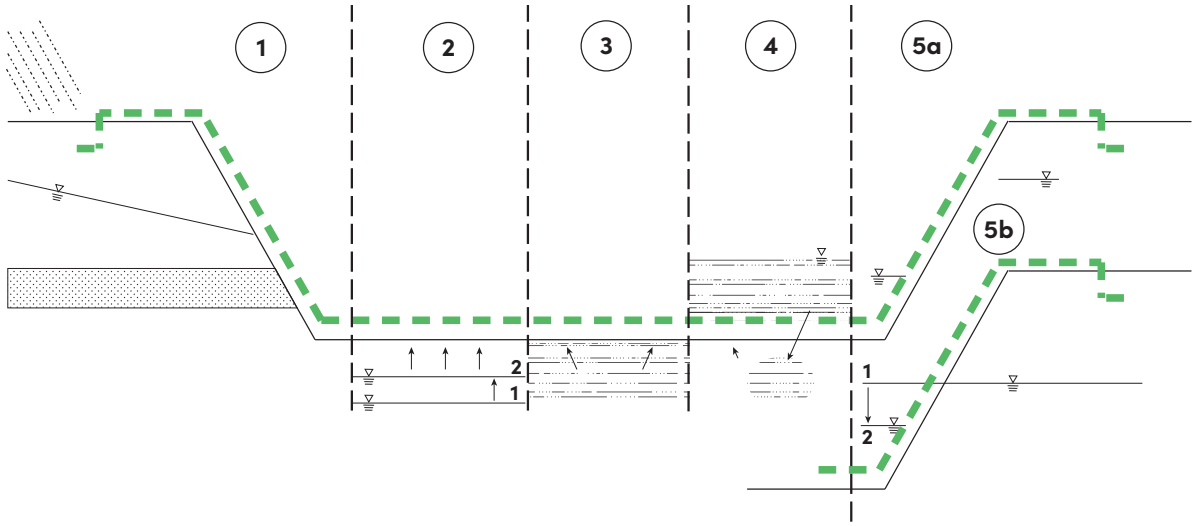
3.3. DRAINAGE

Uplift pressures under a geomembrane due to gas or water can decrease the lifespan of a project. It is important to verify if your project is subject to these under-pressures and design a drainage system for the gas or water, in order for it to not distress the geomembrane.

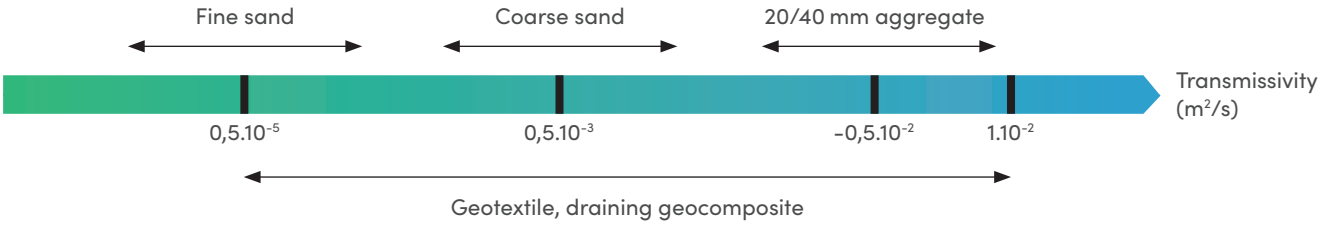
The principal causes for uplift pressure under a geomembrane are as follows:

- The presence of a waterproof surface and temporary liner (rain);
- Compression of unsaturated gases under the ground due to the rise of underlying groundwater
- Decomposition of organic matter;
- Leak in a basin of liquid loaded with organic matter;
- The level of the water table is higher than the level at the bottom of the basin;
- Quick drainage of a basin in equilibrium with the outside during the service period (permanent water or supplied by a leak).

Principal causes of uplift pressure under a geomembrane



The diagram below is for information purposes only. It lists relative transmissibility with respect to various types of 0.5-m thick porous ground.



3.3.1. GAS DRAINAGE

Any gas located under the waterproofing geomembrane can be detrimental to a project, particularly due to the under-pressures that it can cause. The accumulation of gases under a geomembrane creates a localized upward pressure which can lift the liner. These gases can be linked to the rising of the water table or to the decomposition of organic matter in soil. When the ground that is to be covered with a geomembrane is composed of these soils greater than 1 meter in depth, it does not make economic sense to remove the soil. Instead, special precautions can be taken to prevent pressure differentials.

WHERE GASES ORIGINATE

Referring to Figure below, gases may come from:

- The fermentation of soils in the support ground (usually with carbon dioxide or methane) - Fig. 1;
- Soils with organic pollution and/or air trapped between the liner and the ground - Fig. 3;
- Rising water table that puts the air contained in the interstices of the soil under pressure - Fig. 2.

Presence of gas under geomembrane

Fig. 1

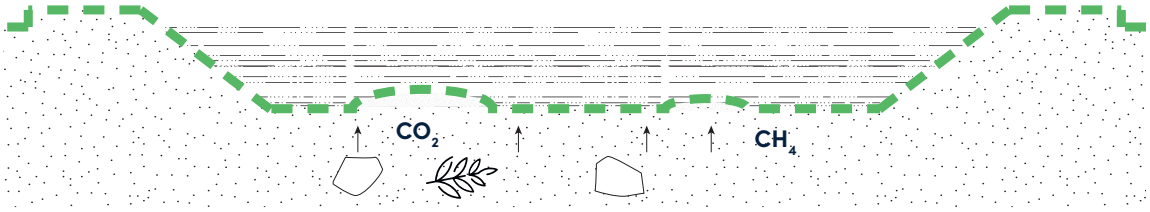


Fig. 2

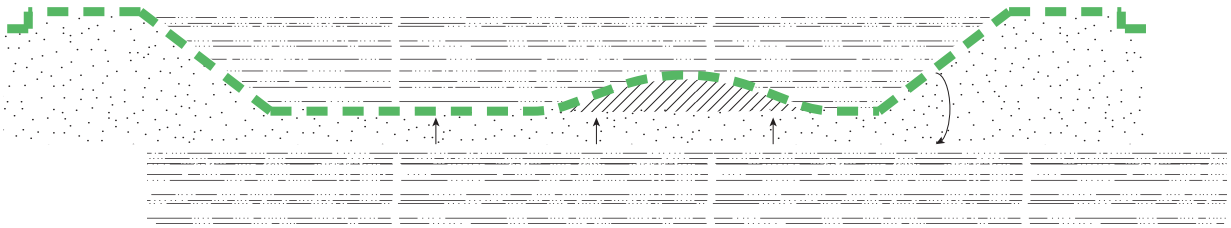
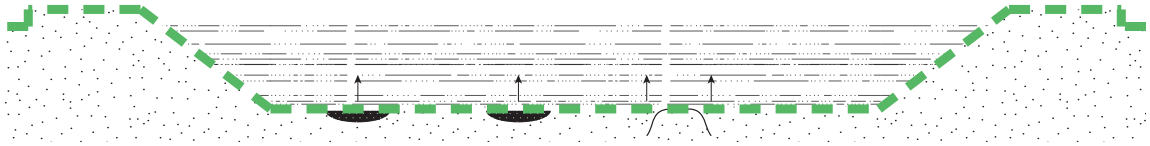


Fig. 3



RESULTS OF GAS PRESSURE

A waterproof geomembrane can act as a barrier to upwards gas circulation. The rising of gas circulation may accumulate under the geomembrane and create pockets, whose pressure is high enough to lift up large areas of geomembrane. These pockets would create tensions in the geomembrane which can rupture the material by bursting, thus requiring costly remedial works.

▲ Hippopotami in a pond

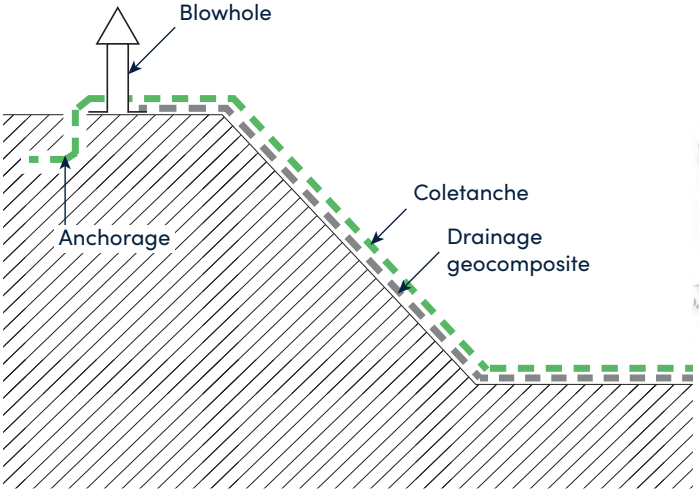
▲ Under drain

These created tensile stresses in the membrane can also generate residual strains, which creates areas of weakness in the geomembrane presented by deformations. These defects can reduce the lifespan of the project.

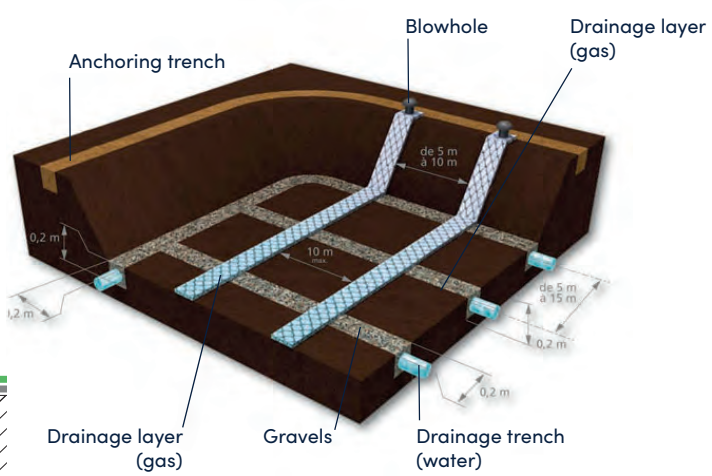
SYSTEM

A simple solution to prevent lifting of the liner is to install a drainage layer between the ground and the geomembrane with a network of flexible gas evacuation strips. An efficient system is to lay the strips in a grid pattern on the surface at regular intervals in the sand, running along the bottom of the basin and the slope, venting at the crest through prefabricated blowholes.

Drainage system



Water and gas drainage



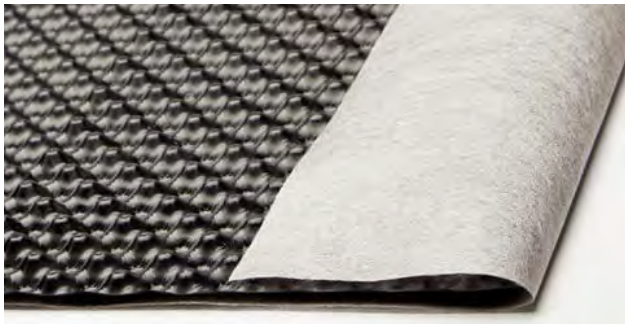
Gas venting cannot function if submerged. It can be done on a whole surface according to a grid system adapted to suit each site.

The biogas evacuation system must be waterproof. An accurate, comprehensive study of biogas evacuation requirements should be analyzed to ensure good functioning of the structure. Failure to do so could result in serious problems and greatly reduce the lifetime of the structure. Such studies should also take into consideration that it is essential to avoid air pockets under the geomembrane caused by pressure differentials between the air and the liquid in the basin.

DRAINAGE LAYER

For many projects it is important to systematically include a gas drainage layer under the geomembrane, which allows gas to discharge towards higher points. The drainage layer could be a drainage geocomposite, composed of a geospacer and geotextile, made to adapt to the flow capacity, mechanical resistance, and distributes the under-pressures.

There are a number of drainage layers offered in the geosynthetic industry such as non-woven geotextiles, geonets, geocomposites, etc.

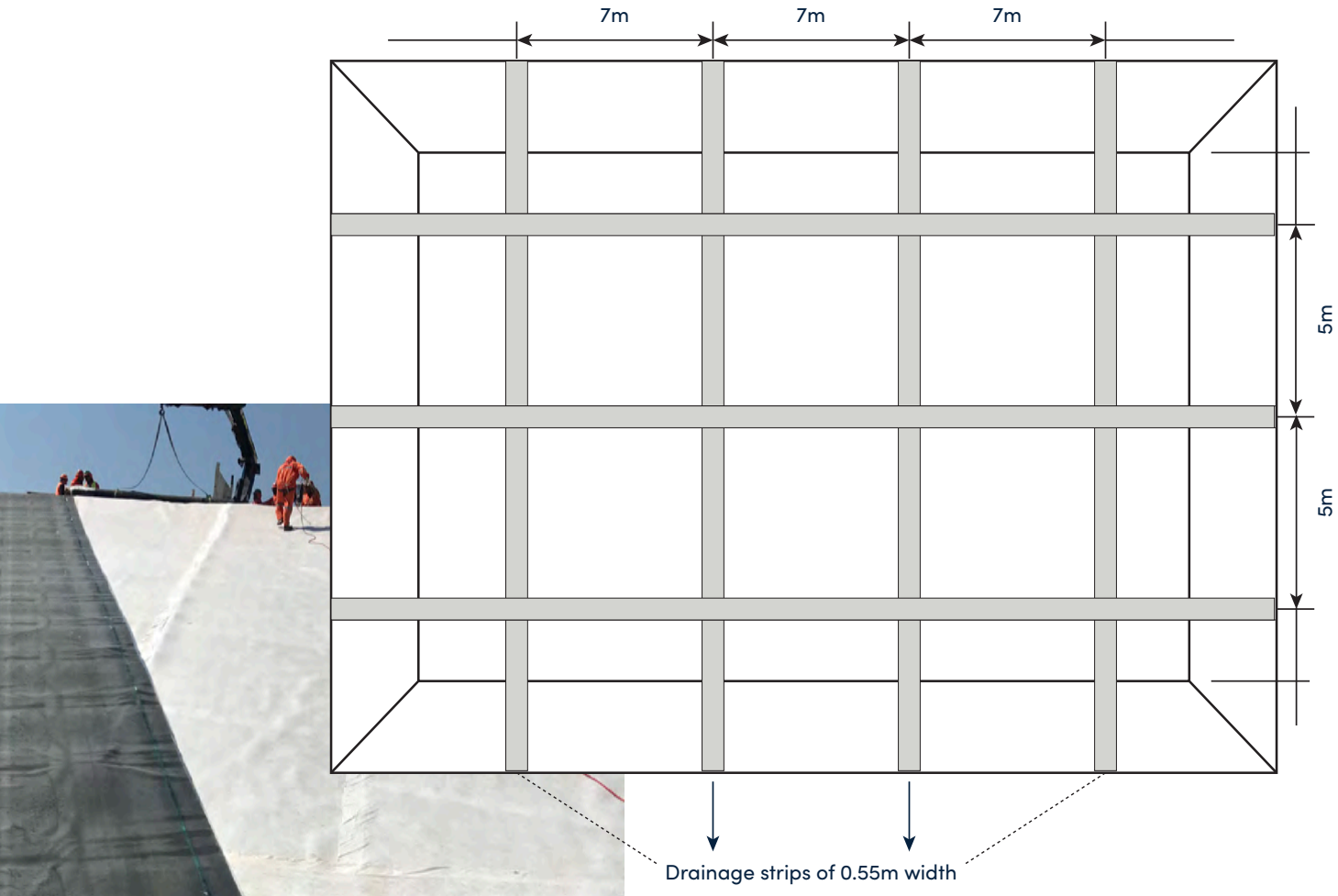


▲ Drainage layer composition — *Elydan website elydan.eu*

STRIPS

The strips are made of a geospacer between two geotextile filters to catch gas as close as possible to its production. The strips are laid in a grid pattern on the surface at regular intervals in the soil. Smaller interval distances with more strips laid provides a more efficient system, since a narrow system will permit the gas to find a quick exit to the atmosphere more than a dispersed system. We recommend a maximum 10m spacing and the system should cover 10-30% of the basin's surface all in one block. It is recommended for the strips to be placed at a minimum 1m distance from the welded sections of the geomembranes. A more precise calculation of the strip interval spacing or the number of strips can be done by the products' suppliers, which will integrate the predicted variation of the water table, the fermentable nature of the soil, and the gas transmissivity of the ground.

Grid Layout of Basin surface strips



The Solpac manufactured strips are 6mm thick, 0.55m wide, and up to 100m in length. The opening of filtration is 130µm with compressive strength of 450 kPa. The strips are resistant to creep in compression under 150 kPa for every 10 years and have a tensile strength of 22kN/m.

BLOWHOLES

Venting outlets (blowholes) are positioned at the highest points and must be protected by a cap and grating to prevent any obstruction or penetration of water. The use of Wavin blowholes provides a smart, strong and easy-to-apply solution.

The Wavin manufactured blowholes guarantee the continuity between draining strips and release gas in a chimney effect, created by a succession of increasing volumes from the volume inside the strips to the volume inside the vent. The standard blowholes have a base diameter of 220mm with a 200mm height, although can be custom designed if needed.

▲ Three parts of Blowhole to be assembled on site

During the installation of the blowholes, in order for the gas to escape throughout the life of the structure, the vent must:

- Prevent the penetration of water in the system (the vent should not be submerged in order for it to function);
- Have a device to prevent the intrusion of insects and all other wildlife;
- Withstand climatic events such as storms or simply UV;
- Be of sufficient height to ensure the removal of gas by a chimney effect;
- Be exposed to the atmosphere in order to allow gas to exit.

▲ Blowhole installed on Coletanche geomembrane

3.3.2. WATER DRAINAGE

Geomembranes can be lifted up by sudden rises in the ground water level that is normally below the bottom of the basin. The rising ground water pushes the air trapped between the water and the geomembrane upwards, lifting the geomembrane. A drainage layer is often required under the geomembrane to drain water inlets from the ground or on the geomembrane to catch leachate (in the case of landfill cells), in order to limit the hydraulic load applied to the geomembrane and avoid soil destabilization.

When the water table rises, air contained in the interstices of the ground between the water and the geomembrane is put under pressure. The geomembrane would be uplifted by the water pressure. It is therefore advisable to monitor the water levels over a long-term period (between 10 to 30 years), to be protected against a long-term change of the water table level.

It would only be possible to empty the basin completely if the level of the ground water were lower than the bottom of the basin.

A draining soil must meet the following conditions:

- Equivalent to sand over 40 % as per the following equation:

$$\frac{D_{60}}{D_{10}} \leq 3$$

Where D_{60} *= mesh size that allows 60% of the grains through,*
Where D_{10} *= mesh size that allows 10 % of the grains through*

If the drainage network support is a fine soil, a filter blanket is needed to prevent blockage of the drain. This is the case if the condition $d_{15} \leq 5 \times D_{85}$ is not met:

d_{15} = mesh size that lets 15 % of the drain material through,
D_{85} = mesh size that lets 85 % of the underlying earthen material through.

- The filter blanket may be an non woven geotextile or a material that meets the value expressed above.

DRAINAGE LAYER

An efficient drainage system provides a solution to this phenomenon. The system would be similar to the system described in the Gas Drainage section. The drainage layer would drain the water seeping through the capping earth so there is no additional load due to water.

The water drainage layer is either:

- Made of a geotextile filter surrounding granular material in trenches;
- Made of layers of drainage material;
- Completely prefabricated by assembling together

geotextiles or pre-shaped geospacers (appearing as large width sheets);
- Made to collect water from the low points.

Drainage layers are unrolled on the subgrade and embankments. They must adapt to a project in terms of resistance to long term compression filling the basin, and flow capacity according to obtained flow rates determined by a valid case study. The drained water can be accumulated in a drainage collector and should be evacuated to another location through a drainage pipe.

SUGGESTION

There are a number of drainage layers offered in the geosynthetic industry such as non-woven geotextiles, geonets, geocomposites, etc. However, you can decide amongst other drainage solutions to better fit your needs such as drainage soils, aggregates, or other materials you have readily available on site.

3.3.3. EXTREME TEMPERATURES AND TEMPERATURE VARIATIONS

In the case of HDPE geomembranes, temperature variations cause shrinking and important expansion (continuous stress), wrinkling, and stress on anchors. This is particularly the case for HDPE geomembrane since large temperature variations are common during installation.

High temperatures and temperature variations accelerate ageing and increase the flow of polymer geomembrane.

Coletanche bitumen geomembranes, on the other hand, have a very low thermal expansion coefficient of $0.22x10^{-2}$mm/m/C (ASTM D696) and resist extreme temperatures (-35 °C) and linear dimensional changes at elevated temperature of 0% (ASTM D1204).

3.3.4. ULTRAVIOLET RADIATION

Depending on their composition, geomembranes are more or less sensitive to ultraviolet radiation. The thicker they are, the better their resistance.

Coletanche has superior resistance to ultraviolet radiation because of its thickness and sanded surface.

3.3.5. GROUND SETTLING AND HEAVING

Generally speaking, the flexibility of Coletanche geomembranes allows them to mould to normal surface irregularities. Nevertheless, settling and heaving is expected, and a support structure must be installed to limit such shifting, especially differential soil movements.

This can be accomplished in one or more of the following ways:

- Localized purging;
- Increasing the thickness of the subgrade;
- Compacting the subgrade.

Rigid structures should be avoided as much as possible in geomembrane waterproofing systems installed on soft ground.

The design and execution of the procedures to fasten the geomembrane to rigid structures such as concrete blocks, conduits, etc. must take into consideration the differential movement of the underlying ground.

3.3.6. EROSION AND COLLAPSE OF UNDERLYING GROUND

Certain types of ground may be washed away (gypsum, quarry fill, demolition and mining waste, certain volcanic and moraine soils, etc.). These can be serious problems that generally require remediation.

Precautions must be taken to prevent superficial erosion of the geomembrane support layer caused by:

- Leaks;
- Infiltration of runoff water under the geomembrane around poorly designed or built anchors and accompanying work;
- Heavy precipitation before the geomembrane is installed;
- Water inflow from outside the structure (springs, runoff, etc.).

3.3.7. ICE

Ice can cause the following problems:

- Lateral pressure as the ice forms;
- Stresses caused during water level variations creating a wrenching moment;
- Damage by floating ice.

A few precautions can be taken to limit potential ice damage:

- Protective structure (granular base, smooth concrete slabs, etc.);
- Slabs of compressible materials (ballasted polystyrene);
- Double the Coletanche geomembrane at the places of possible wrenching.

3.3.8. FLOWING LIQUIDS (CANALS, BASIN INTAKE AREAS, AERATED LAGOONS)

Flowing liquids strain the walls of structures through friction (tangential strain) and turbulence.

These strains increase with the flow rate, measured by the Manning Coefficient. Coletanche has an excellent Manning coefficient which is similar to a trowel finished concrete lined canal newly constructed. This also means that the flow rate would be higher for a given length of canal waterproofed with Coletanche.

▲ Meyreuil canal, France

The Manning coefficient ranges from 0.010 for a smooth concrete lined channel to 0.15 for a weed filled earth channel. The Manning Coefficient for Coletanche is 0.012, with a Strickler Coefficient of 83. These values were estimated assuming a perfectly flat geomembrane with no wrinkles or defects. Such defects are likely to exist in most installations which will affect the n value and the admissible shear stress the Coletanche may be able to withstand.

Some of the factors that will affect the nature of the flow in the channel include:

- The quality of the subbase under the Coletanche;
- The quality of the contact between the subbase and the Coletanche;
- Slack in the Coletanche which may lead to wrinkles, bumps, or folds;
- Inclination of the channel;
- Quality of the water in the channel (amount of particles carried).

Friction and impacts from material in turbid liquids can abrade, puncture, and tear geomembranes. The following solutions can help prevent this from happening:

- Use a geomembrane like Coletanche that is sufficiently resistant and thick;
- Decrease the turbidity (degritting zones);
- Incorporate a protective structure.

3.3.9. WAVES AND WASH

Waves and wash caused by wind and passing boats cause alternating hydrodynamic stresses on the bank.

The correct support structure and geomembrane thickness must be used to protect the bank from such stresses.

3.3.10. DREDGING AND MAINTENANCE

Dredging and maintenance operations during the normal life of the structure must be planned for, during the design of the geomembrane waterproofing system.

A protective structure such as a layer of asphalt or concrete at the bottom of a basin is occasionally required to allow trucks and loaders to circulate.

3.3.11. DRIFT (FLOATING OBJECTS)

Drift, including ice, can cause tears in the geomembrane by impact, contact, or friction.

▲ Riprap being installed

A protective structure or measures to reduce the amount of drift or to prevent it coming into contact with the geomembrane can be incorporated into the design of the geomembrane waterproofing system.

The risk of damage increases with wave amplitude and thus with the size of the water body.

3.3.12. HEALTH AND BIOLOGICAL STANDARDS

GENERAL

The components of Coletanche geomembranes meet the standards for the transport and storage of liquids (irrigation water, drinking water).

REQUIREMENTS

The manufacturer respects the standard ISO 14001.

POTABILITY

The Coletanche bituminous geomembranes can store drinking water.

Coletanche is NSF/ANSI 61 certified, which is an agency that sets health effects criteria for many **water system components. This certification ensures that the product** meets the regulatory requirements for the U.S. and Canada, and it can often meet or fulfill the testing requirements for many other countries as well. The NSF certification is a mark of distinction that provides customers with assurance that the product is safe for use in drinking water.

NSF/ANSI 61 testing covers all products with drinking water contact from source to tap, and determines what contaminants may migrate or leach from your product into drinking water. It also confirms if they are below the maximum levels allowed to be considered safe.

Volume of the pond required by the certification should be greater than 75,000 gallons (284 m^3).

Coletanche has also passed water potability standards for Australia and New Zealand, *AS/NZS 4020 Testing for products for use in contact with drinking water.*

▲ Bel Air reservoir, Maryland, USA

▲ Estanques Pirque, Santiago de Chile, Chile

▲ Roza reservoir, Washington, USA

3.3.13. DESIGN SERVICE LIFE

The service life of a structure also enters in the choice of the geomembrane waterproofing system.

Economic studies must take into consideration the following investments:

- Cost of investment;
- Maintenance cost;
- Replacements cost;
- Required service life.

Coletanche has a very long service life. As an example, the Atomic Energy Commission in France and the Nuclear Safety Agency in the United States chose it for the storage of low and medium specific activity radioactive wastes after seven years of study.

▲ La Hague, France

The requirement was 300 years in France and 1,000 years in the United States.

3.3.14. VEGETATION

UNDER THE GEOMEMBRANE

Vegetation growing under the geomembrane waterproofing system could perforate the geomembrane and geosynthetic clay liners.

To prevent this risk, it is necessary to use a geomembrane like Coletanche, which includes an anti-root at its base, called PET film.

When Coletanche is used for capping applications with top-soil covering the geomembrane, vegetation can be expected to grow. Therefore it is suggested to use Coletanche up-side-down (i.e. PET film visible rather than sand). In such cases, please contact your Coletanche representative beforehand.

ON TOP OF THE GEOMEMBRANE

Vegetation such as shrubs can be planted on a geomembrane waterproofing system as long as the depth of the soil is adequate for their root systems.

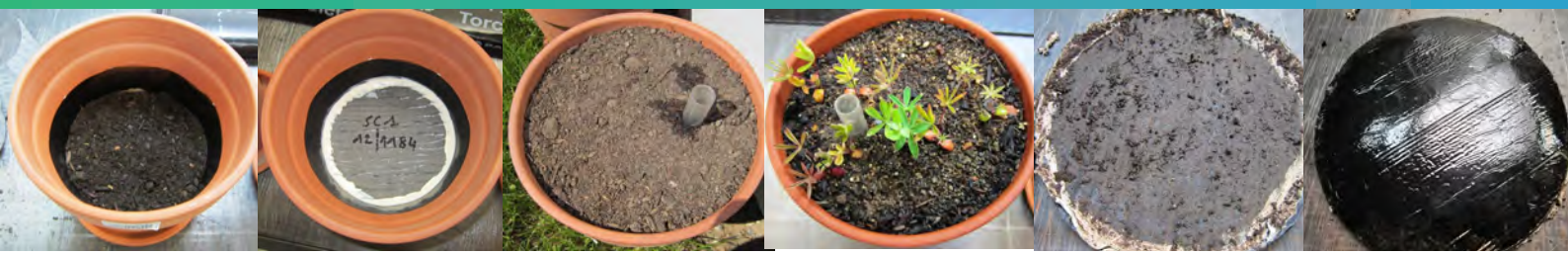
Experience has shown that, in general, once the roots reach the geomembrane they run along the surface of the geomembrane.

3.3.15. ANIMALS

Because Coletanche is a robust reinforced material, it is resilient against potential interactions with animals; however, regular traffic or repeated circulation of large animals (cows, deer, etc.) at the same place may cause damage.

If animals are known to aggressively burrow at an installation area, a protective structure of compacted gravel, as shown below, mitigates this problem.

Root barrier testing



3.3.16. COVERING

The choice of using covering materials should be in the following cases:

- Mechanical limitations;
- Vandalism;
- Vehicle traffic in the empty basin (cleaning);
- Animal traffic;
- Shifting of the subgrade;
- Pressure surges under the geomembrane;
- Wave action, floating bodies, ice, etc.
- Boat hulls striking the geomembrane.

▲ Protective structure of compacted gravel

▲ Soil cover layer being applied on a mineral sands waste cap

▲ Landfill Cap with gas extraction and soil cover system

4. INSTALLATION

4.1. PRELIMINARY STEPS BEFORE WATERPROOFING

4.1.1. ACCESS AND STORAGE

ACCESS TO SITE

During the preliminary visit before the beginning of the works, site access must be carefully studied for the delivery of materials, so as to avoid delays for the excavator which will handle and transport them, and for unloading to be done in the best conditions.

As the access road is generally located at the top of the slopes. A good access path must be provided to avoid site congestion, allowing:

- The supply truck access and the in-situ storage of the rolls, accessible in case of required extra rolls;
- The refueling of equipment;
- The location for possible anchor trenches (a width of roughly 1.50 m);
- The progress of the project without risk of damaging the geomembrane under site traffic.

STORAGE AREA

In order to allow a proper unloading of the trucks that deliver rolls from the plant, a storage area where the rolls are temporarily stored must be organized. The ground must support the weight of the rolls and the traffic of the handling equipment.

The rolls must not be stored directly on the ground due to risk of puncturing several layers of the roll. They should be laid on specific supports, taking into account the distance between the bottom of the roll and that of the mandrel, which is approximately 35 cm (14in). Examples of supports include:

- Two layers of concrete blocks (if no multiple loading and unloading are forecasted);
- Reinforced concrete safety barriers;
- Metal trestles or I-beams;
- Wooden beams.

Short term storage of up to 1 month on the ground can be permitted after evaluation from a site QA/QC engineer.

▲ Different types of storage for the rolls

Each roll occupies a surface area of 5 m^2 (54 ft^2), thus, the dimensions of the storage area will be calculated depending on the projected installation output. An entire container (9 to 11 rolls depending on grade) will require 45 to 55 m^2 (485 to 592 ft^2) and a full truck (9 to 12 rolls depending on local weight requirements) needs a 60 m^2 (646 ft^2) storage area. Additional space for handling varies depending on the vehicle used (shovel, crane, loader or crane truck).

ON SITE VEHICLE ACCESS

The access roads for vehicles supplying the rolls are generally at the top of the embankment, where access problems are anticipated. A sufficiently large width (minimum 5m or 16.4 ft. is recommended) should be guaranteed to allow the following:

- Supplying vehicle access;
- Storage of rolls;
- Refueling the vehicles;
- Location of an anchorage trench (approximately 1.5 m or 4.9 ft).

4.1.2. SAFETY CONDITIONS ON SITE

As the sites on which waterproofing works are generally carried out have steep slopes (canals, ponds, landfill cells), it is important to ensure access to the site is prohibited, mainly by adding a surrounding fence.

If some sections of the project already contain large water surfaces and volumes, emergency exits for workers must be provided in case of accidental falls (ropes, ladders, etc.).

Although the weight of a Coletanche roll is approximately 2 metric tons, thefts or damages to the geomembrane cannot be excluded. Site and storage installations must therefore be organized to cope with this risk.

It is recommended to always have two people working together around a basin.

4.2. PROJECT PREPARATION

4.2.1. DEVELOPMENT

During the preparation stage, it is important to check the following with the client:

- the overall design of the project has not been modified between the tender phase and the construction phase;
- and the project will be used according to the description that was given with the request for quotation.

A letter confirming the parameters used for the choice of geomembrane is indispensable.

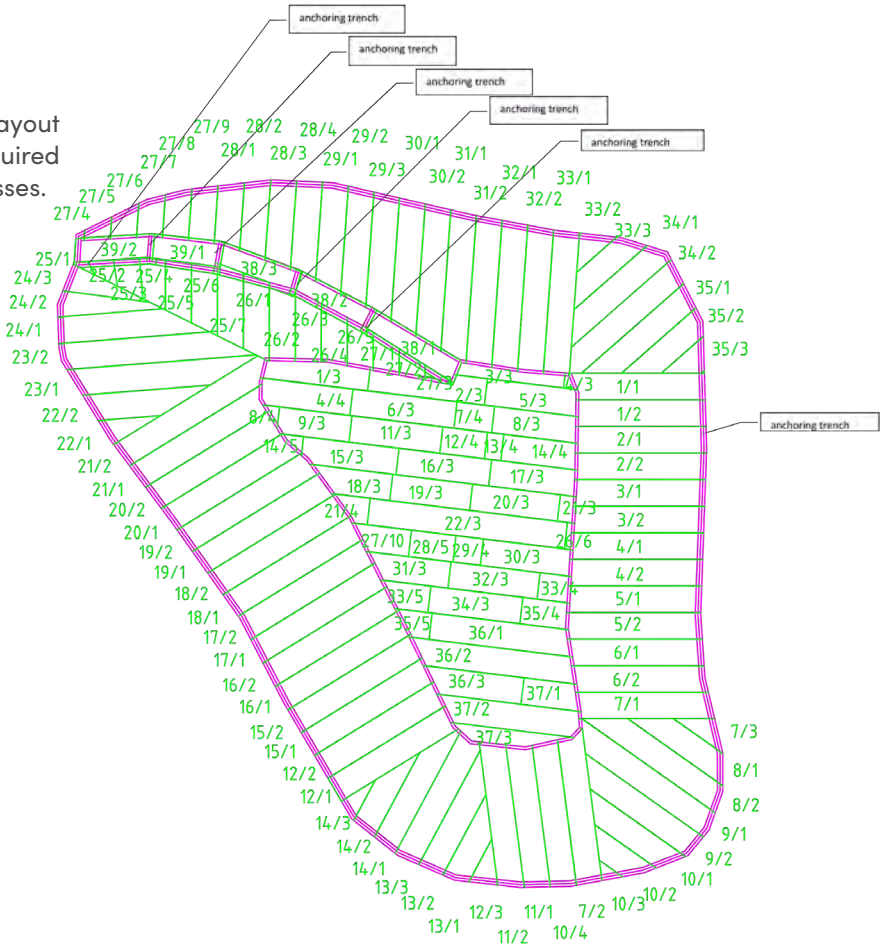
The following points should be specifically checked:

- Pressure on the geomembrane (water height, waste height);
- Identification of the products to be stored (chemical content);
- Mechanical constraints that the geomembrane will undergo (traffic of maintenance and cleaning machines, turbulence of stored liquids, number of agitators in a lagoon, agitator power, etc.);
- Access by third parties close to the geomembrane during or after the works.

4.2.2. GEOMEMBRANE LAYOUT SCHEME

Before ordering the rolls, a geomembrane layout plan must be prepared to determine the required geomembrane surface and to minimize the losses. This surface will include the 20 cm seam overlap, anchoring surfaces and cuts.

The amount of material loss with respect to the finished surface varies between 5 to 10 %, sometimes more depending on the geometry of the work.



4.2.3. STANDARD PACKAGING

In their standard packaging, the Coletanche rolls have the following dimensions:

The standard length of the steel mandrels is 5470 mm (17.9 ft), with inner diameter of 168 mm (6.6 inches), and outer diameter of 178 mm (7 inches).

A 20 cm (8 inch) strip, located under the left side of the membrane in standard production, is covered with a PE silicone film instead of terphane, in order to protect the seam edge and allow for removal during installation.

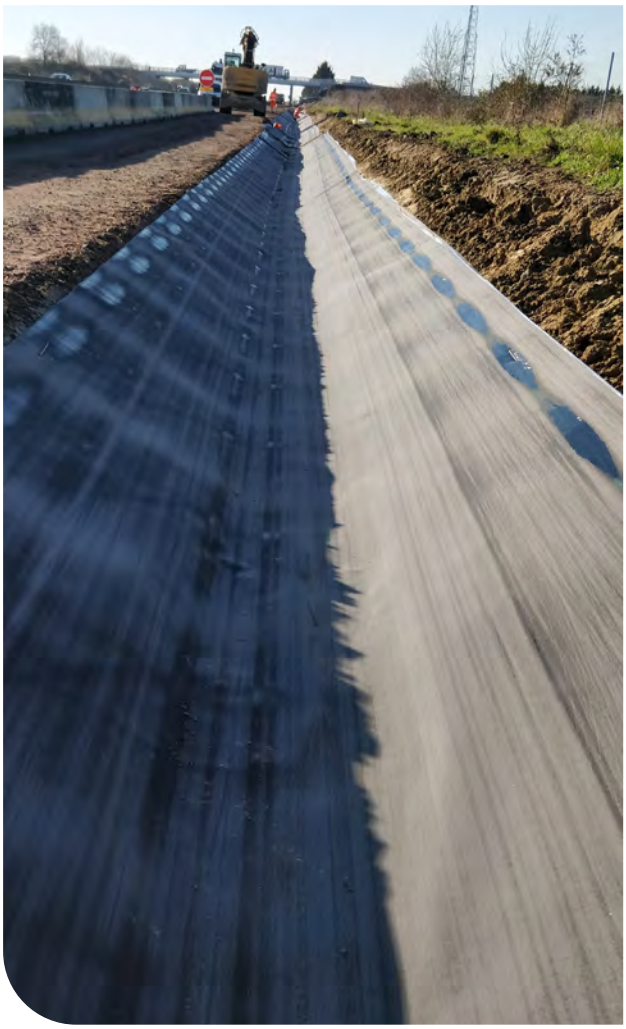
Most of the rolls are one single piece. However, due to manufacturing constraints some may have a transversal cut (no more than 30% for deliveries over 12 rolls). A cut roll is identified by a marker tape and the roll identification label. More information on two piece rolls can be found in section 4.3.3. of this document.

4.2.4. SPECIAL ORDERS

Specific productions (width, length) can also be manufactured upon request.

The conditions for custom width manufacturing are as follows:

- Minimum width with one strip per roll: 3.00 meters;
- The terphane film covers the whole surface of the geomembrane;
- In all cases, one edge of the geomembrane will be close to the end of the mandrel (about 20 cm), which means that the Coletanche strip will not necessarily be centered on the mandrel.



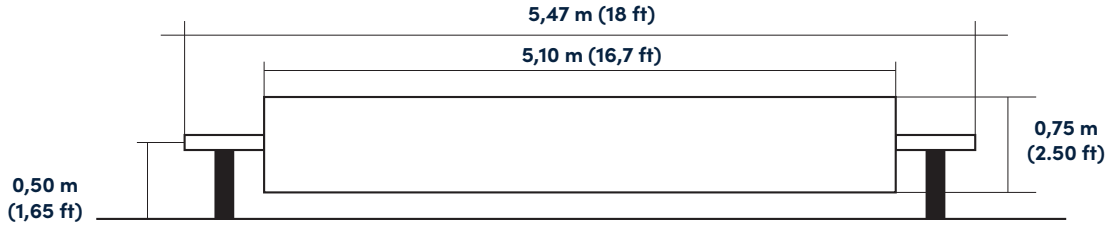
▲ Ditches, Jules Verne

▲ Ditches, A63, France

4.2.5. RELEASE FILM

The standard position of the PE silicone film is on the left side when facing the strip while unrolling. For some applications (canals,) where the overlapping of seams must be installed in the flow direction, it may be necessary for the PE silicone film to be positioned on the other side. For some projects, it can also be useful to have it on both sides.

If this is the case, it should be requested prior to ordering the membrane.



▲ Laying Coletanche overlapping in the flow direction, which required different positions of the PE silicone Film depending on the side of the canal

4.3. SITE PREPARATION

It is imperative to organize a meeting between the installer and Coletanche before the beginning of works:

- 15 days for building sites of less than 20 000 m^2 (215 200 sq ft);
- 1 to 2 months for building sites of more than 20,000 m^2 [215 200 sq ft] or sites that are difficult to access. (example: altitude mines close to the polar circle).

The purpose of this meeting of preparation is to:

- Present Coletanche: It is often helpful if all the workers on the site attend the slide presentation;
- Verify worker availability: number and skill level (training and certification of welders);
- Verify material availability:
- Heavy equipment (hydraulic excavator and handling beams);
- Personal protection equipment;
- Other material;
- Temporary ballast;
- Verify the logistics:
- Unloading area with sufficient load bearing capacity to support large lorries/temporary storage;
- Availability of roll supports;
- Storage of mandrels;
- Organization set-up;
- Return of mandrels to warehouse;
- Verify concrete forms and, if possible, use rounded ones;
- Verify slope stability:
- Coletanche is not intended for formwork;
- Reinforce the slopes using lean mortar, for example;
- Plan workers and material to repair the surface of the slopes after heavy rains;
- Present the geomembrane layout scheme;
- Respect for the environment: waste management (polyethylene film, PE silicone film, etc.);
- Verify already placed Coletanche orders and orders to be placed;
- Delivery lead time;
- Site visit;
- Verify grading work;
- Specify required quality;
- Verify site access.

▲ Installer training

4.3.1. ORDERS

Once the contractor has been selected, orders must be sent in writing to Coletanche in order to determine the plant production schedule.

Invoices are issued by Coletanche and must be paid according to the usual conditions.

Note that the amount ordered must, in general, be 5% to 10% greater than that indicated in the geomembrane layout scheme. This is to cover overlaps and material losses due to structural geometry.

4.3.2. DELIVERIES

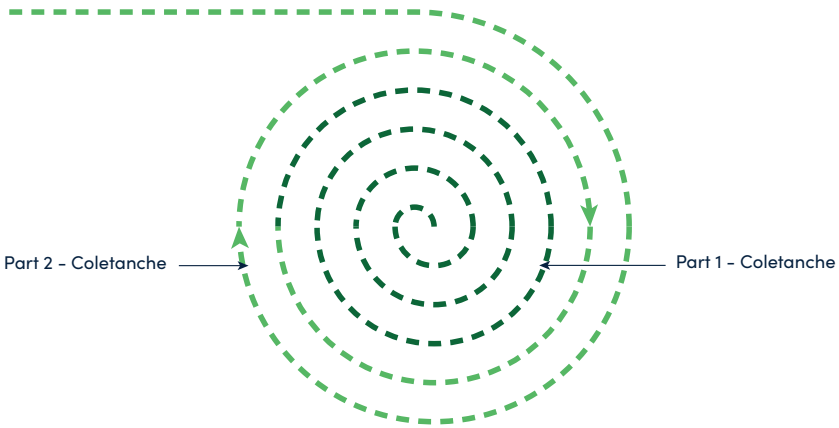
Deliveries for less than 12 rolls are typically carried out directly from a local warehouse.

A flatbed truck can carry from 9 to 12 rolls depending on the local weight restrictions. A 20-foot container can carry from 9 to 11 rolls depending on the final weight and roll dimensions.

4.3.3. LABELING

The rolls are marked with the following labels:

- Identification label, with the following mentions:
  - Type of Coletanche;
  - Length of the section(s);
  - Serial number;
- ASQUAL label (if applicable);
- Cut rolls – «Roll in two pieces» label when relevant, with the precise length of each element;
  - For two piece rolls, the label will indicate the length of both pieces. The first number is the piece closest to the mandrel and the second number is the piece which will come off of the roll first.



▲ Identification Label

4.3.4. RECEIVING THE ROLLS

Each delivery is accompanied by a packing list detailing the roll dimensions and serial numbers of the corresponding rolls.

The person in charge of receiving the delivery should:

- Verify that the packing list is in accordance with the numbers indicated on the rolls and the order;
- Proceed with a visual inspection of the rolls, and carefully look for possible damages;
- Sign the delivery note only after this careful inspection of the delivery.

In order to document the final quality control report, photos of each load should be taken before unloading the rolls. The person in charge will then fill in the rolls acceptance form.

4.3.5. UNLOADING

Usually, the delivery will be carried out by regular 20' sea-containers each containing 11 rolls maximum.

▲ Coletanche rolls in a container

Usual characteristics of a 20' sea-container

Weight	2,300 kg	
Internal dimensions	Length	5,90 m
	Width	2,35 m
	Height	2,40 m
External dimensions	Length	6,10 m
	Width	2,45 m
	Height	2,60 m

▲ Delivery: container

Unloading container

The container must be unloaded by the installer or the purchaser at his own expense by the site entrance within two hours of its arrival (extra charge can be applicable for late unloading). Therefore a loader or a forklift equipped with a special pin to put inside the mandrels is required for the unloading procedure. If necessary, the fabrication drawings to build the unloading pin can be sent to you.

Please note that, while drawings can be provided for your use, the unloading pin cannot be manufactured in our facilities, due to the variability of the attachment to the construction machines (loader or forklift). The pin will have to be fabricated on site or nearby. The drawings sent to you will have to be adapted according to the construction machine to be used.

◂ Unloading pin
- Diameter:14 cm
- Length: 353 cm

▲ Attachment to the machinery

▲ Insert the pin inside the mandrel

▲ Slightly lift the roll: the full weight of the roll should only be on the pin once it is fully inserted into the mandrel

▲ Pull the roll carefully

Truck Delivery

When making a delivery by truck, tilt trailers or flatbeds are used. They can hold up to 12 rolls depending on the maximum weight allowed in the country. Unloading the rolls should be done within two hours of the truck arrival (extra charge can be applicable for late unloading). The cargo has to be secured with straps (6 straps are a minimum). Refer to local requirements for any additional securing elements.

Unloading is done using a spreader bar equipped with adapted slings or clamps, to avoid damaging the roll. You should also be able to unload using a hydraulic or manual beam safely, even if it can be cumbersome.

Forklifts are prohibited!

The use of a forklift is prohibited because forks may puncture the rolls. Patching a puncture can give the installer a fair amount of additional work.

▲ Unloading using a spreader bar from a special open top container.

▲ Roll unloading

4.3.6. STORAGE

ACCESS

Proper access must be taken into account to reduce the loss of time. Also the access roads should be strong enough to bear the weight of the rolls and to allow the flow of vehicles handling the rolls.

TEMPORARY STORAGE AREA

Surface needed

On the ground, each roll occupies a surface of 5 m^2, thus, the storage area will be of calculated dimensions depending on the projected rhythm of supply and installation output. An entire container (11 rolls) will require 55 m^2 and a full flatbed (12 rolls) needs a 60 m^2 storage area. Additional space for handling varies depending on the vehicle used (shovel, crane, loader or crane truck).

Operations

The rolls should not be stored directly on the ground due to the risk of puncture that can occur through the various layers of the roll. They should lay on adapted rigid supports such as:

- Concrete blocks;
- Reinforced concrete safety barrier;
- Metal trestles or I-beams;
- Wooden beams.

▲ Storage using concrete blocks

▲ Roll distribution according to used surfaces

When storing rolls, the distance between the bottom of the roll and that of the mandrel, which is approximately 35 cm, must be taken into consideration.

In addition, by taking into account the future installation order on site (type of membrane, length, position of the overlap protection, rolls in two pieces), sorting the rolls out in the temporary storage could avoid preventable maneuvering.

Storage on construction site

When the site is completely set up, the rolls should be removed from the temporary storage area to be transferred to the construction site in the most regular way possible, and as close as possible to the installation site; they should be stored on cinder blocks or beams.

▲ Storage using wooden beams

▲ Storage using concrete blocks and wooden beams

Transfer of the rolls to the installation area

The circulation road for vehicles supplying the rolls being generally at the top of the embankment, circulation problems should be anticipated. A sufficiently large width (our recommendation is 5 meters minimum) should be guaranteed to allow the following:

- Supplying vehicle access;
- Storage of rolls;
- Refuelling the vehicles;
- Location of an anchorage trench (approximately 1.50 m).

A short transfer could be done with an excavator and a beam. For a longer transfer, it is recommended to use a trailer hauled by the vehicle used to unload the container.

▲ Example of machinery used to transfer the rolls

4.3.7. PRODUCTION CERTIFICATES

The purpose is to certify:

- The manufacturer's stated quality;
- The reliability of the properties of the product.

This implies that during production, the following tests are carried out in the plant laboratory for:

Raw materials

- Mass per unit area of the geotextile and the glass fleece;
- Mechanical resistance of the geotextile;
- Penetration of the binder;
- Filler content.

Finished goods

- Width;
- Thickness;
- Mass per unit area;
- Width of the welding for each roll;
- Tensile strength behavior;
- Resistance to static puncture.

A certificate is sent with each delivery, stating that each roll complies with the requested specifications.

Individual certificates showing the test values on finished goods can be provided, if such a request is made when placing the order.

If a specific tender requires test frequencies, this must be mentioned with the price request.

XP range rolls delivered have the ASQUAL International Certification.

GEOMEMBRANE ASQUAL ACCREDITATION IS GIVEN BY:

A technical committee made up of users, test laboratories, and manufacturers after:
Auditing the plant and receiving the results of tests on random samples sent to Colfrac-certified independent laboratories equivalent to GAI LAP (Geosynthetic Accreditation Institute – Laboratory Accreditation Program).

4.4. SUBGRADE PREPARATION

4.4.1. SURFACE ASPECT

The subgrade layer must be:

- Carefully and uniformly compacted. A special attention must be brought around intrusions (concrete walls, footings, pipes, etc.) where a careful manual compaction is necessary;
- Free from sharp edges that might damage the geomembrane (such as sharp protruding stones);
- Free from vegetation or organic content whose decomposition would lead to gas production and soil compressibility degradation;
- Free from ruts where the geomembrane might get over tensed under the weight of the protective layer and the load of the structure. When the excavator that carries the rolls moves on the subgrade, it must be located on the side of the strip it is unrolling, so that rutting on the subgrade can be corrected by hand, just before laying the next strip. In particular, when the geomembrane is subject to hydraulic pressure, **it will adapt very quickly to any irregularities of the subgrade.**

To avoid such problems, it is necessary **to prepare the subgrade carefully,** with leveling and mechanical compaction, and often a hand clearing of the surface with a rake.

Evenness defect on a large scale can be tolerated, up to 5 cm (2in) over a 3m (10ft) length, as the geomembrane elasticity will compensate for the elongation. On the other hand, small defects are much more critical, as they lead to a strong stress concentration over a few centimeters, and the geomembrane will be subject to major elongation rates that may exceed its capacity.

▲ Subgrade preparation

▲ Leveling of the subgrade with a loader

▲ Raking of the subgrade

▲ Excavator working along the laying strip, allowing fine leveling of the subgrade before laying the geomembrane

If the clearing does not compensate enough for the unevenness of the subgrade, it may be necessary to fill in the voids either with sand on the horizontal parts, or with lean mortar on the slopes (sand will not stay on the slopes), or with a geotextile having the appropriate mechanical properties.

4.4.2. TRANSITION AREA AT BASE OF SLOPE

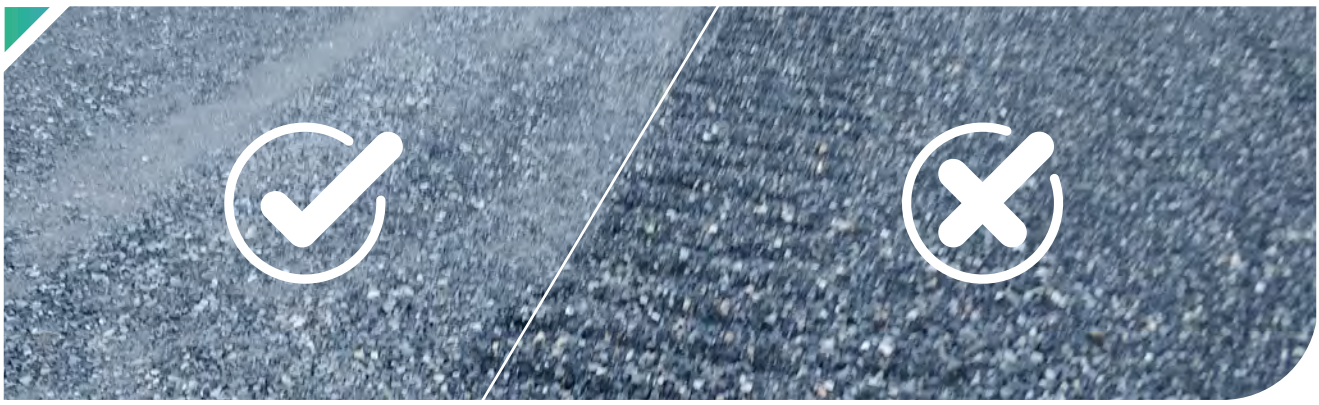
The transition between the slope and the bottom of the structure must be as smooth as possible, with a rounded shape of a minimum radius of 20 cm (8 inch), to avoid tensions in that area of the geomembrane.

The bottom of the structure must have a slope of 3-4 %, with a high point around the periphery in order to properly drain or clear the site, and in order to facilitate the expulsion of air bubbles caused by poor biogas evacuation.

4.4.3. HAND OVER PROCEDURE

After the density and bearing capacity tests, a visual inspection of the subgrade must be carried out together with the client and the company in charge of the construction of that layer, before starting the waterproofing operations.

Indicate and resolve all possible subgrade problems (quality of the subgrade, damage to concrete, etc.) prior to the installation of Coletanche.



▲ Do not hesitate to refuse a subgrade if its quality is not as good as requested

5. OPERATIONS

5.1. INSTALLATION OF A COLETANCHE GEOMEMBRANE

5.1.1. TYPICAL CREW

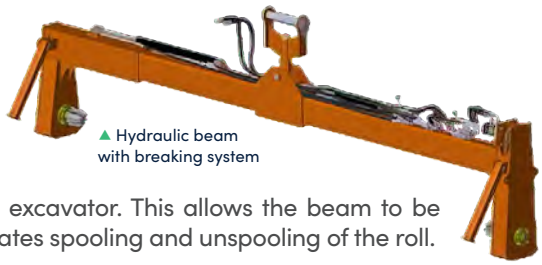
A typical laying crew includes:

- A foreman;
- Three workers for geomembrane handling and temporary anchoring;
- An excavator driver.

If the unrolling beam is not equipped with a hydraulic motor, at least two additional workers must be provided to pull the strips.

Care must be taken to prevent residual strain in the geomembrane.

If the support layer quality is bad, (sharp stones or ruts) and requires correction just before laying the geomembrane, additional workers with rakes, and maybe a small compactor are needed.



▲ Hydraulic beam with breaking system

5.1.2. HEAVY EQUIPMENT

Rolls are handled with a 20 to 25 ton hydraulic excavator that is tracked, if possible. There are two kinds of handling beams:

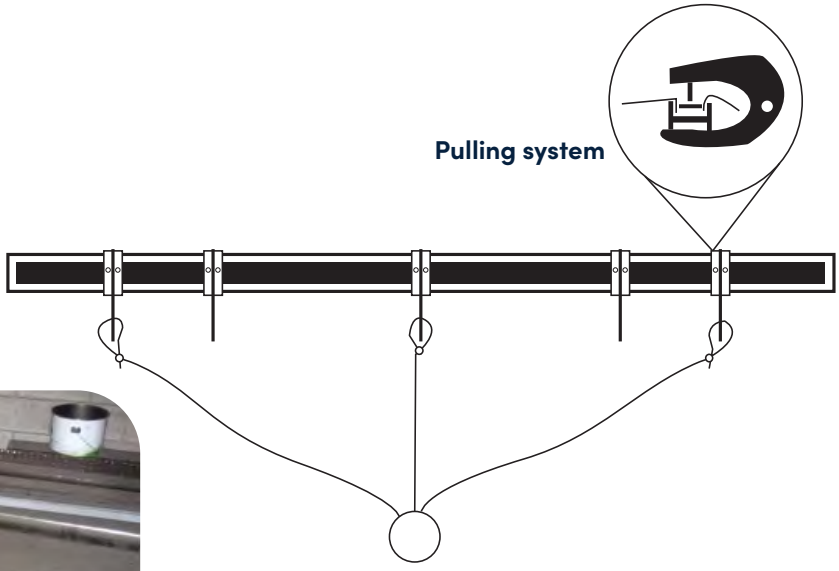
- **Hydraulic beam:** The Hydraulic Beam is connected to the hydraulics of the excavator. This allows the beam to be expanded and contracted to connect to the mandrel and a drive motor facilitates spooling and unspooling of the roll.

- **Manual beam:** Manual beams specially made for deploying Coletanche can be made. These beams can feature conical mandrels mounted on ball bearings and a braking system to control for risk of the geomembrane unrolling out of control. Another more simple manual beam design consists of a 100mm steel tube with a plate on one end inserted inside the mandrel of the roll.

▲ Manual beam

▲ Mandrel mounting point on the Hydraulic Beam

It may also be necessary to provide a winch on the opposite side of the site when long lengths are installed, to overcome the effect of friction between the geomembrane and the ground. Various types of specialty equipment can be fabricated for this purpose.



▲ Trestles, for manual unrolling in the restricted places

5.1.3. PERSONAL PROTECTION EQUIPMENT (PPE)

General construction safety regulations apply to geomembrane installation projects.

Main risks are:

- Falling or slipping along the slopes, with risks of fracture or sprain;
- Cuts when using cutting tools on the geomembrane;
- Burns when welding the geomembrane.

PPE includes:

- Safety shoes or boots;
- Safety helmets for staff moving within the roll handling area;
- Safety jackets;
- Handling gloves;
- Heat resistant gloves;
- Safety harness and anchoring system;
- Brooms and rags to remove water following light rain (care must be taken for sharp edges – place rags where the slope ends for the rope-ladders);
- Cotton clothing or fire resistant fabrics.

All clothing should be made of cotton or high fire resistant fabrics

5.1.4. SMALL EQUIPMENT

The small equipment for tracing and cuts consists of:

- Vise-grip cutters with hooked blades for knives. Flat blades are not suitable for cutting Coletanche due to its internal geotextile;
- Knife;
- Builders line;
- Measuring tape;
- Aerosol paint;
- Rope ladders;
- Wax marker.

▲ Rope ladders must always be installed on a slope.

5.1.5. WEATHER CONDITIONS

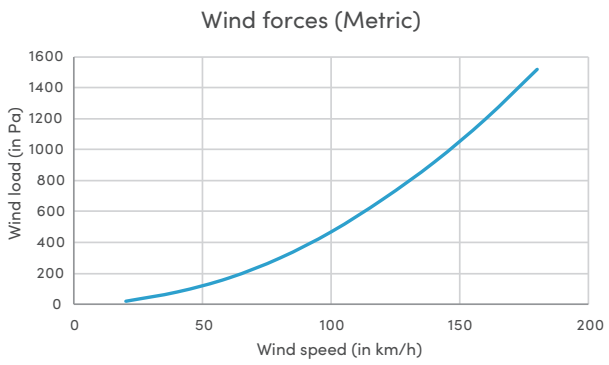
Wind

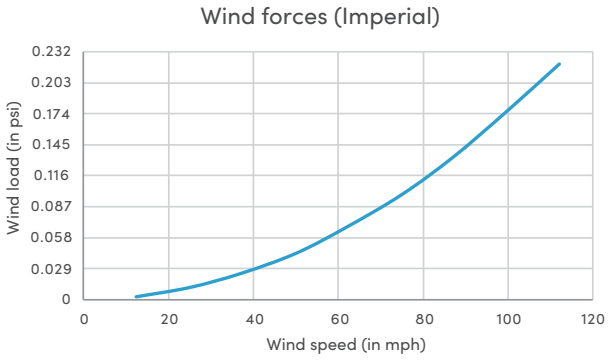
Although the Coletanche geomembrane mass per unit area is higher than that of polymeric geomembranes, it is however subject to the effects of wind, mainly when those effects are reinforced due to the site configuration (canal, trench, whirlwind, Venturi effect on top of a dam, etc).

When the geomembrane is in its final position, with completed welds and closed anchoring, a suction effect can occur and potentially cause lifting and pulling forces on the geomembrane (unless the support layer is porous).

The construction phase is much more sensitive, and temporary ballasting of the strips must be carried out with particular care as soon as they are laid. In particular at the end of each day, if all welds are not completed.

The figure below shows the maximum wind load applied on a placed on a flat surface as a function of wind speed.





Note that 10 Pa equals the pressure of a 1-mm high water column

A factor of safety could be incorporated into the design to compensate for this effect.

▲ Geomembranes lifted by extreme wind during construction process

Wind can also carry solid particles that can damage the geomembrane by abrasion.

If the geomembranes are only turned but do not show any tear, it is generally possible to place them back into their rightful position with the help of day temperature, and the geomembrane won't show lasting defects. If tears or sharp folds appear, the damaged geomembrane must be replaced or patched.

5.1.6. RECOMMENDED DIRECTIONS FOR INSTALLATION

When waterproofing a basin, begin placing the liner from the bottom after making sure that any rainwater has been removed.

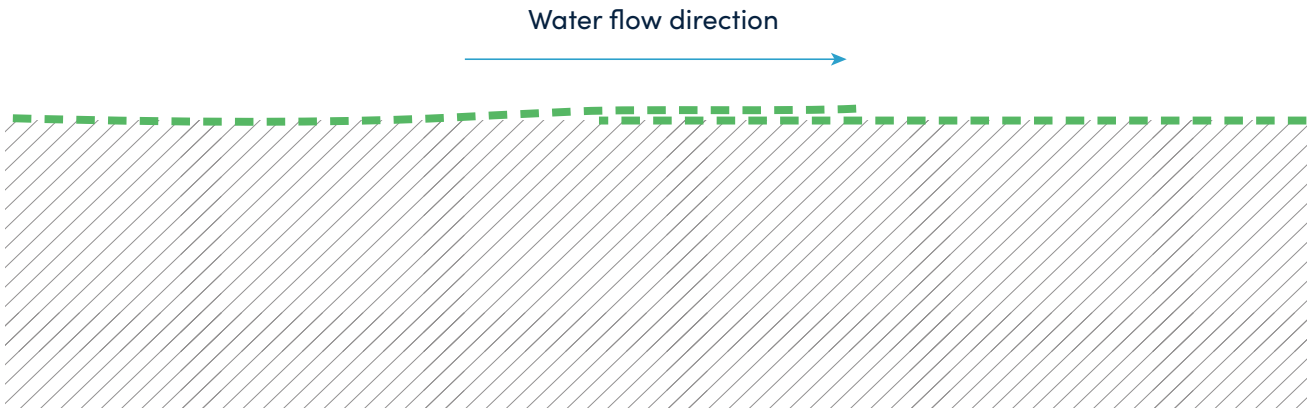
In all cases, if the shape of the project allows it, the laying should be done according to the prevailing flow direction and wind direction.

It would be prudent to suspend installation at wind speeds over 50 km/h (13.9 miles/hr).

Ballasting is helpful to place the liner under high wind speeds.

Principal causes of uplift pressure under a geomembrane

Covering "In tile"



Placing geomembrane in the direction of the current (canals)

5.1.7. OVERLAP WIDTH

There is a green marking indicator as to where to place the overlap for full uncut rolls and to easily guide the workers when laying the strips. For cut rolls, it is necessary to mark the position of the membrane with builder's line or painted marks, to define a minimum 20cm (8 inch) overlap.

It is extremely difficult to move a geomembrane sideways when the overlap is not correct.

5.1.8. LAYING TECHNIQUES AND PROCEDURES

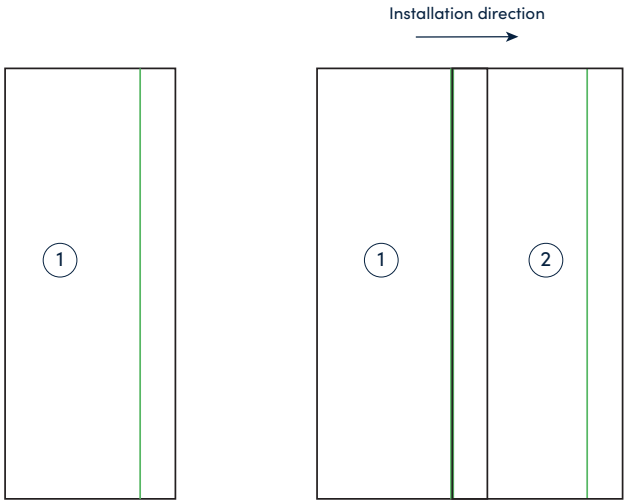
In most cases, the laying of Coletanche is carried out with the terphane (clear plastic film) downwards. The other position may be considered if Coletanche is protected, when, according to the design, a slip plane is required, as the friction angle on the terphane side is much lower (16º) than on the sandy face (34º).

Laying starts from the highest slope, and according to the layout plans previously prepared for the building site. The rolls must be well aligned for proper unrolling along the 20 cm (8'') overlap green marking indicator and follow this alignment.

There is an ideal direction for roll deploying sequence on a slope which ensures that the 20 cm (8'') overlap green marking indicator goes down first and the siliconized release plastic overlays the green indicator.

▲ Use of a hydraulic beam on slopes

This direction is from left to right when facing the roll at the top of the slope. In some instances if this direction of deployment is not possible, the rolls can be deployed in the opposite direction but special care should be taken. In this scenario, the installation will not benefit from the 20cm green indication or the peel away siliconized paper. Therefore, the green indicator will remain on the surface after welding and the anti root film must be burnt away during welding.



Possible cuttings of Coletanche are done using a knife with hook blades, the same one used to cut out the floor coverings.

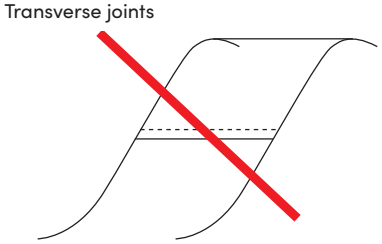
The geomembrane must be held with blacksmith clamps or through notches at the end of the strips.

5.1.9. TRANSVERSE JOINTS

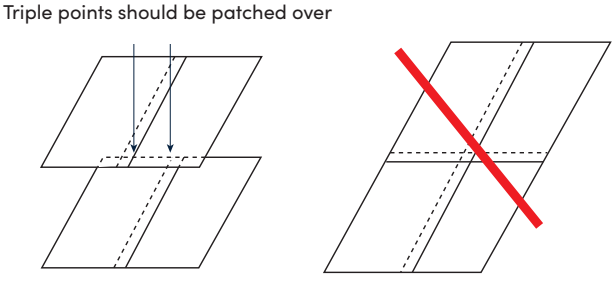
The strips are laid in such a way to avoid:

- Transverse seams on slopes. This should be avoided except in exceptional cases, with the authorization of the client. This constraint must therefore be taken into account when designing the layout scheme and managing the cuts;
- Avoid quadruple points due to misaligned strip ends. Triple points should be covered with an additional geomembrane to secure the weld, and be carefully monitored.

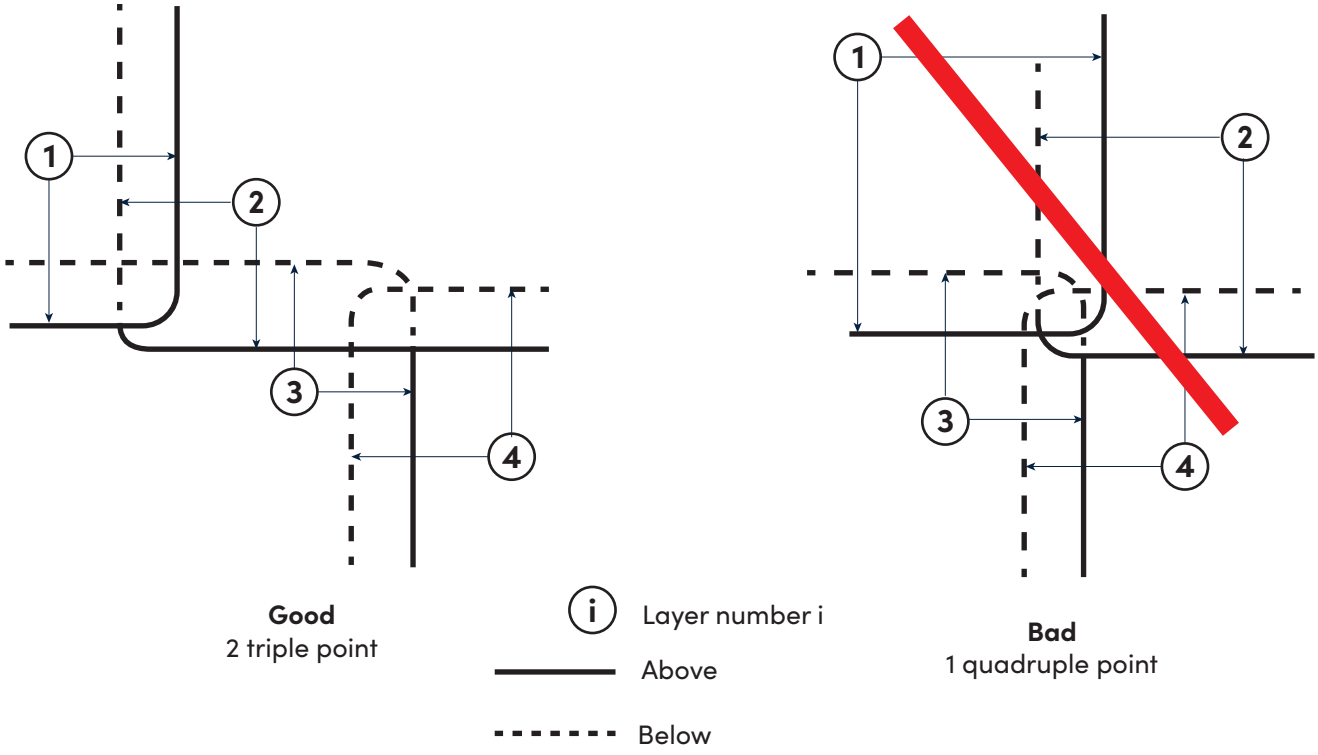
Avoid transverse seams on slope



Multiple layer installation



Multiple layer installation



5.2. ANCHORING AND BALLASTING

5.2.1. TEMPORARY BALLASTING

To resist against the effects of wind during construction phases, the geomembrane must be ballasted with:

- 10 to 20 kg (22 to 44 lbs) sand bags;
- Concrete blocks or filled tires;
- No sharp materials.

The temporary ballast should be evenly distributed on the geomembrane surface, and more particularly along the future seams.

On the slopes, the sand bags can be hung with a rope attached to the crest.

▲ Backfilling materials used as a temporary ballasting

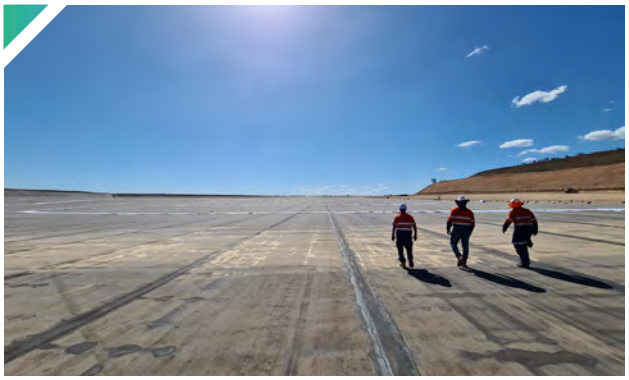
In very windy areas, more detailed studies might be required for prevailing winds and seasonal wind strengths. Suitable material should be on hand for emergency ballasting.

Take measures to ballast against wind gusts after the end of the workday and during weekends.

5.2.2. TEMPERATURE

▸ Maximum

When temperatures in the shade exceed 40°C (104°F), installation of Coletanche geomembranes must be done with caution because the boot marks of workers will leave prints.



▲ Remote Queensland Australia mine

▸ Minimum

It is difficult, but possible, to handle the Coletanche geomembranes below –35°C (-31°F), because the geomembrane becomes too stiff. Installation below -30°C may require heating techniques.

▲ Canadian mine

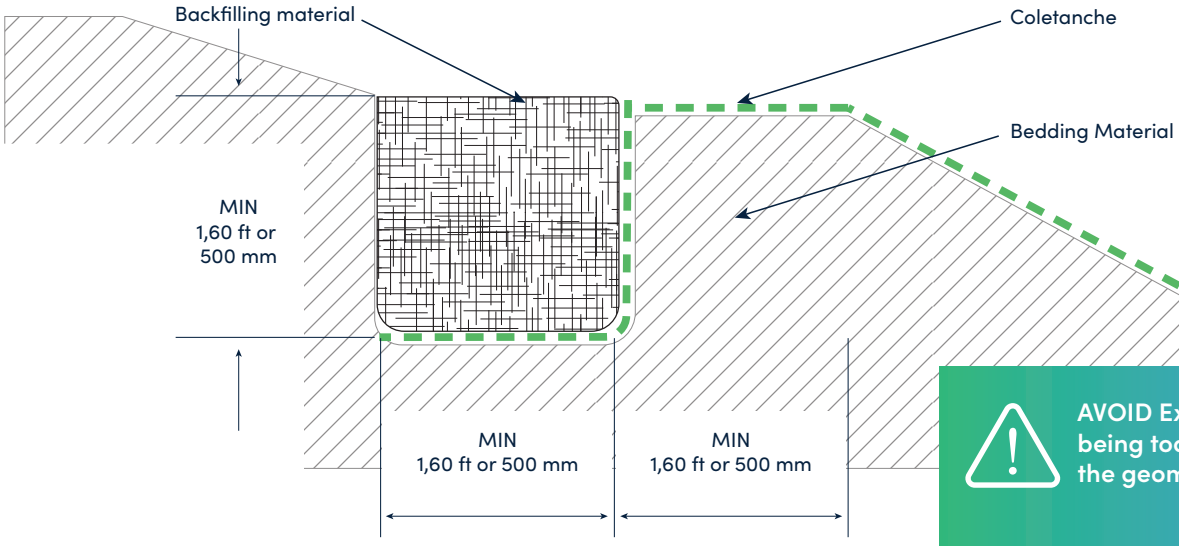
5.2.3. CREST ANCHORING

The proper execution of anchoring at the crest is essential to the behavior of the geomembrane and to prevent creases along the slope.

Three cases can be observed:

▸ **Trench anchoring** (most common)

Bury a section of membrane in a trench dug either by hand or with an excavator or grader, depending on the access to the crest. It should be prepared whenever possible before laying the membrane, to avoid unnecessary and potentially damaging movements of the membrane. A temporary staple can be used at the base of the trench to keep the liner in place if not backfilling immediately.



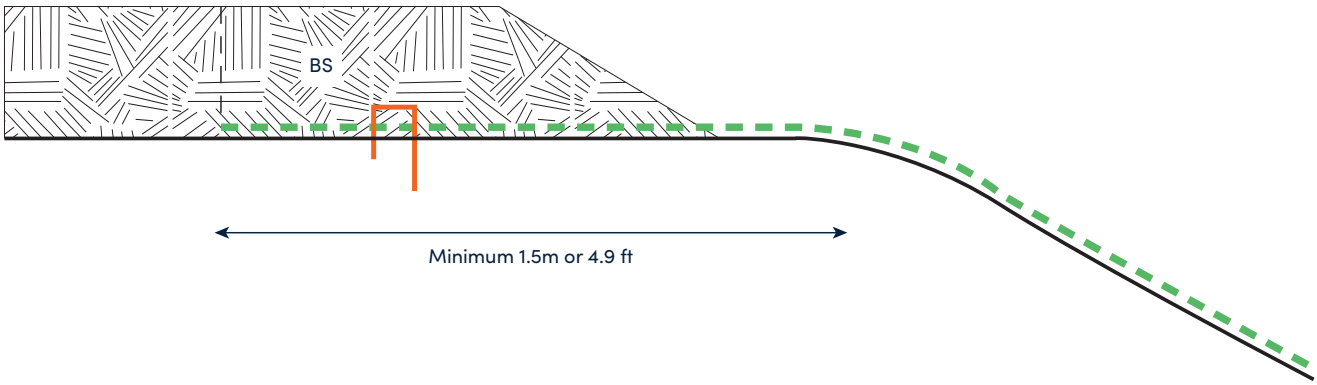
AVOID Excavator being too close to the geomembrane

▲ Anchorage trench

▸ Anchoring through flat ballasting or "runout"

When it is not possible to open a trench, the geomembrane must be maintained with ballasting materials, to avoid erosion effects.

Ballasting anchoring on crest



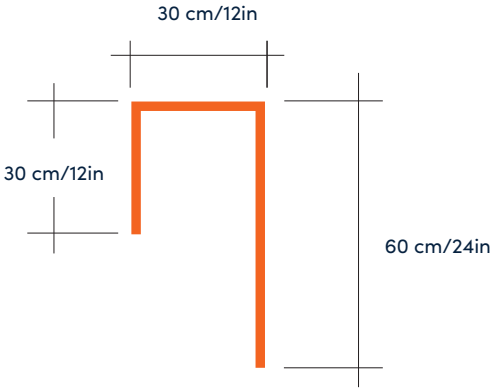
The amount of ballast can be calculated by taking into account the friction angles between the different components (ground, geotextile, geomembrane, protection). The table below gives an approximate estimate of the required ballast.

Ballast profile area in **m²/m** *(inch²/inch), for a 2 tons per cubic meter material (around 20 kN/m³)* ▸

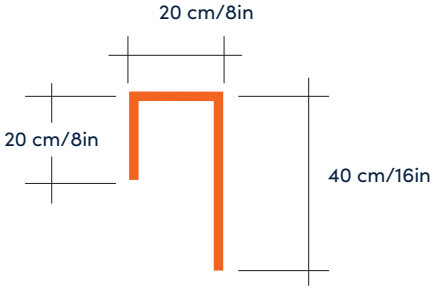
Length of the slope	Little or moderate wind	Strong winds
0 to 3m *0 to 9.8 ft*	0.04 *1.6*	0.06 *2.4*
3 to 5m *9.8 to 16.4 ft*	0.09 *3.5*	0.16 *6.3*
5 to 15m *16.4 to 49.2 ft*	0.16 *6.3*	0.35 *13.8*
more than 15 *49.2 ft*	0.25 *9.8*	0.36 *14.2*

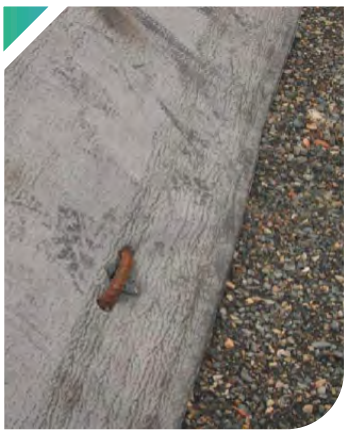
During the construction phase, temporary anchoring may be carried out with metal pins, driven into the ground, which will remain in place after the final anchoring.

In Soft Soil



In Hard/Rocky Soil





Reinforcement bar 12mm Ø

It is advisable to backfill the anchoring trench to avoid water accumulation that might destabilize the ground.

On the other hand, if the support layer is likely to settle, the backfilling should occur only after the structure is put into operation, so that the geomembrane reaches its final position, with minimal internal tensions.

▸ **Mechanical connections**

This can be done with a metal plate, following a bonding or welding of the geomembrane to the support, if it shows a sufficient mechanical resistance.

5.2.4. INTERMEDIATE ANCHORING (BASED ON GEOGRAPHY)

For high slopes, intermediate anchoring may be requested to minimize surfaces subject to wind depression.

Three methods can be considered:

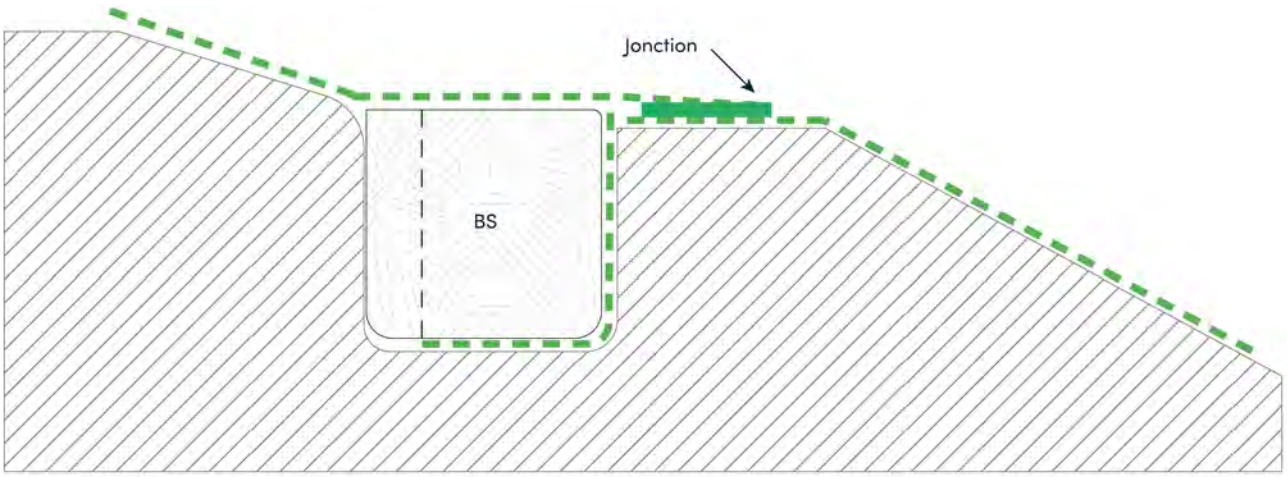
1. Anchoring in a trench along level lines

2. Anchoring in a trench along steepest slope lines :
These two methods should be used only if unavoidable. They are costly, difficult to carry out, and generally lead to damages to the support layer surface.

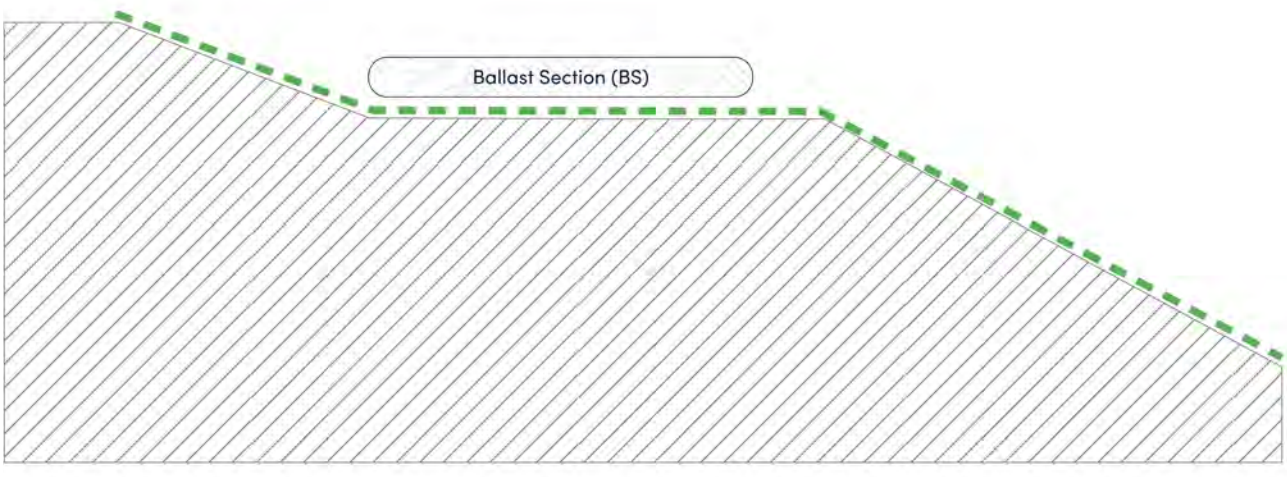
3. Anchoring on a berm
The following schemes show the different types of anchoring that can be carried out on a berm.
Solutions for anchoring on a berm:

- Non-continuous membrane;
- Continuous membrane.

Non-continuous membrane



Continuous membrane

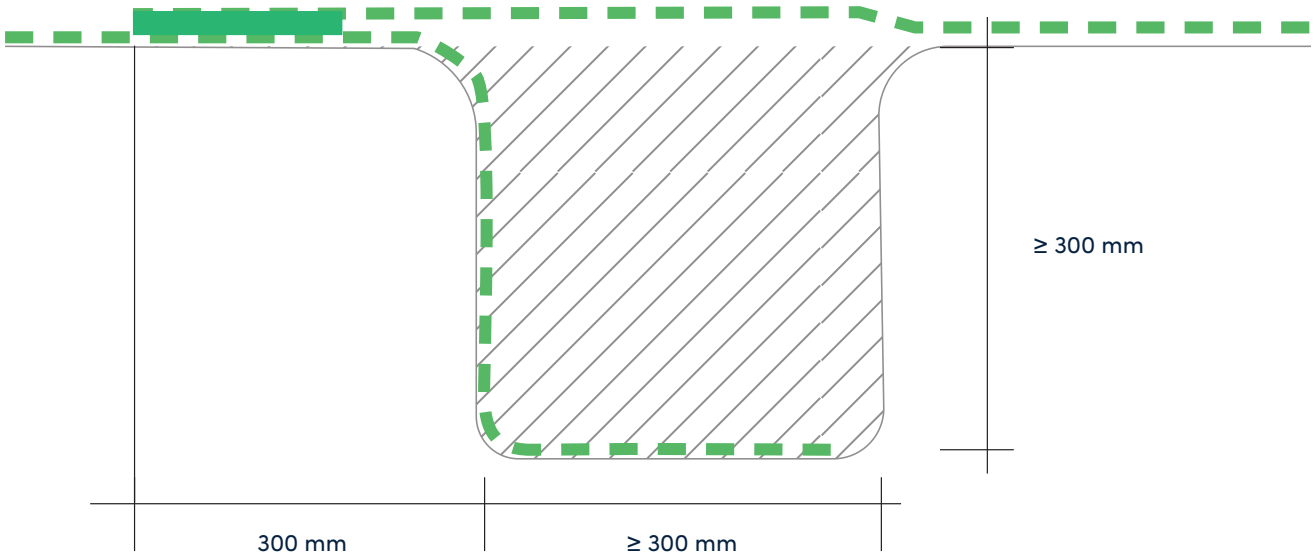


5.2.5. ANCHORING AT THE BOTTOM OF PONDS

The purpose of anchoring at the bottom of ponds is to stabilize the geomembrane on large surfaces and empty basins. A possible solution consists in **anchoring the geomembrane directly at every 4 or 5 strips.**

RECOMMENDED SOLUTION

Anchoring at the bottom of pond with a buried geomembrane



5.2.6. WATERPROOFING AT THE FOOT OF THE SLOPE

For certain structures (for example, dams), the geomembrane must also be anchored at the foot of the slopes to ensure continuous waterproofing protection between the geomembrane and the waterproof base.

These construction details are applied when the bottom of the pond is not lined with a geomembrane with the base material being waterproof (naturally or after special treatment).

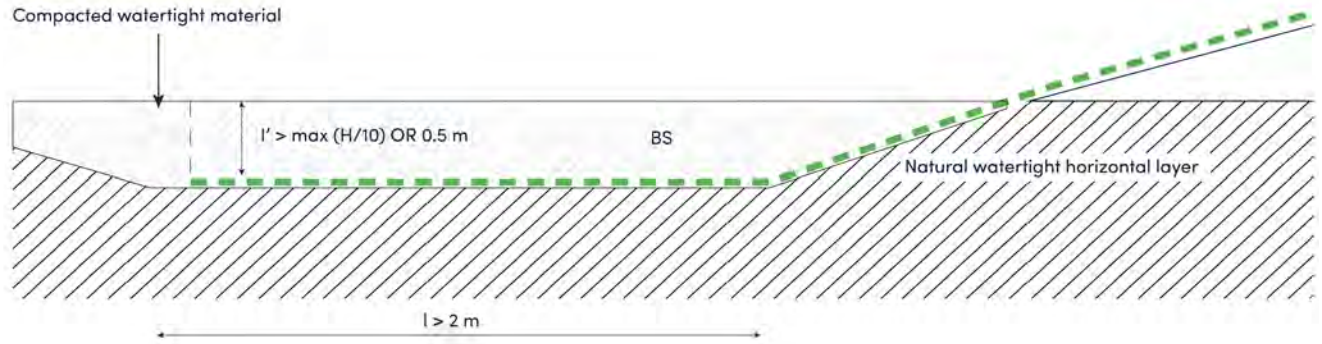
A trench is dug out to the non-porous ground. The geomembrane is placed in the trench, backfilled with a non-porous material (clay, etc.), which is then carefully compacted.

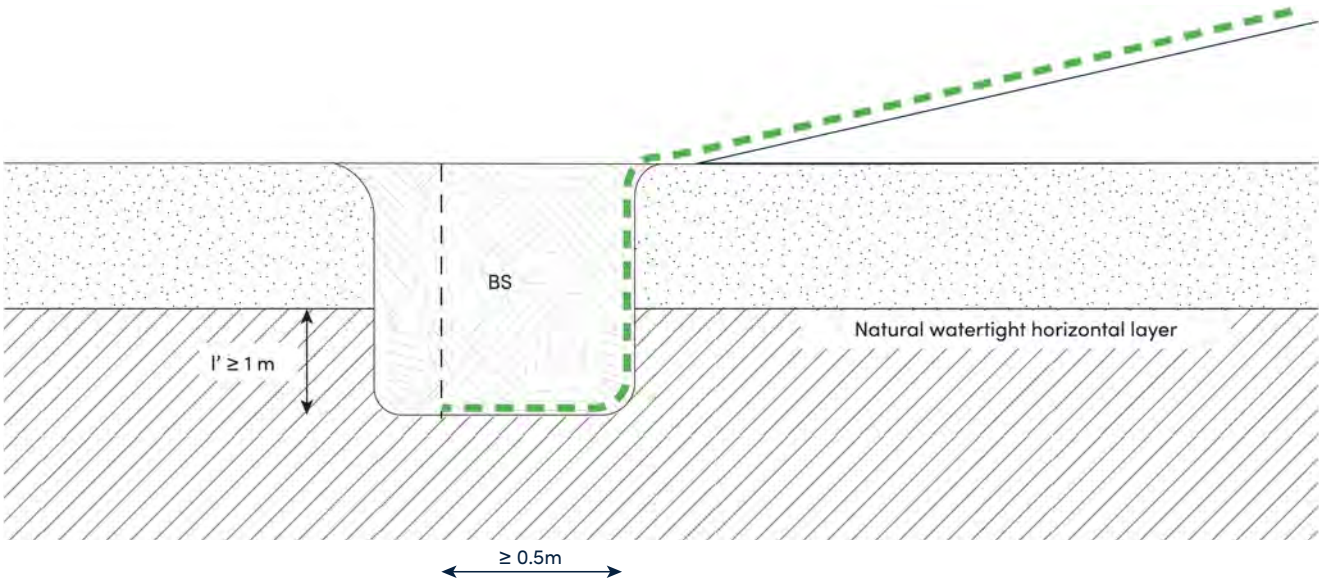
Various overlap procedures are possible (trench or abutment):

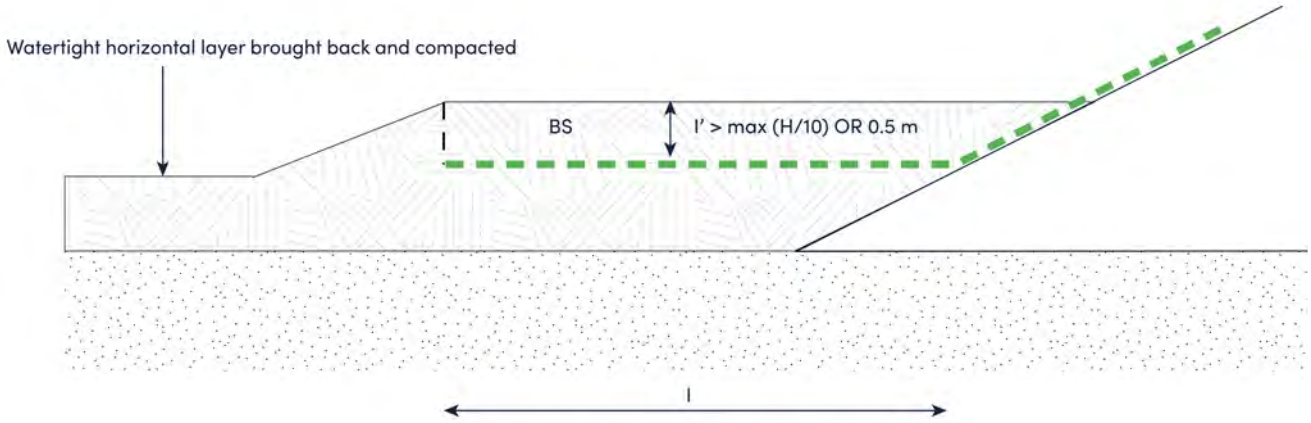
- In the watertight layer;
- With a bentonite-cement grout wall up to the watertight layer;
- With an overlap over a semi-porous material, taking into consideration the acceptable flow rate.

The following figures are various watertight horizon layers and anchoring methods.

Waterproofing at the foot of the slope

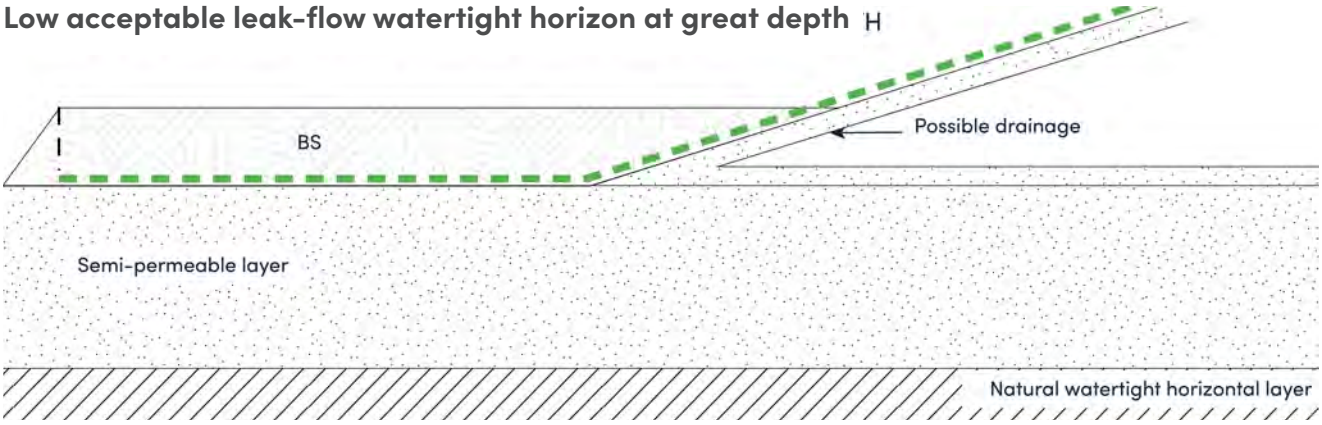




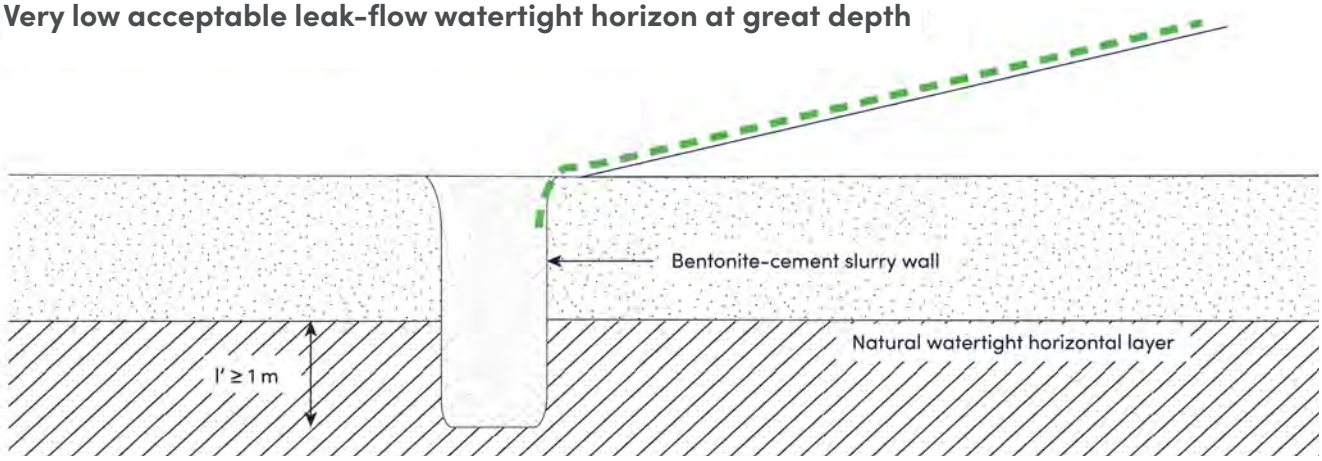


l variable according to the nature of the bottom waterproofing
Example: l > 2m compacted clay, soil treated with bentonite
l > 0,5m waterproof bituminous concrete

Low acceptable leak-flow watertight horizon at great depth H



Very low acceptable leak-flow watertight horizon at great depth



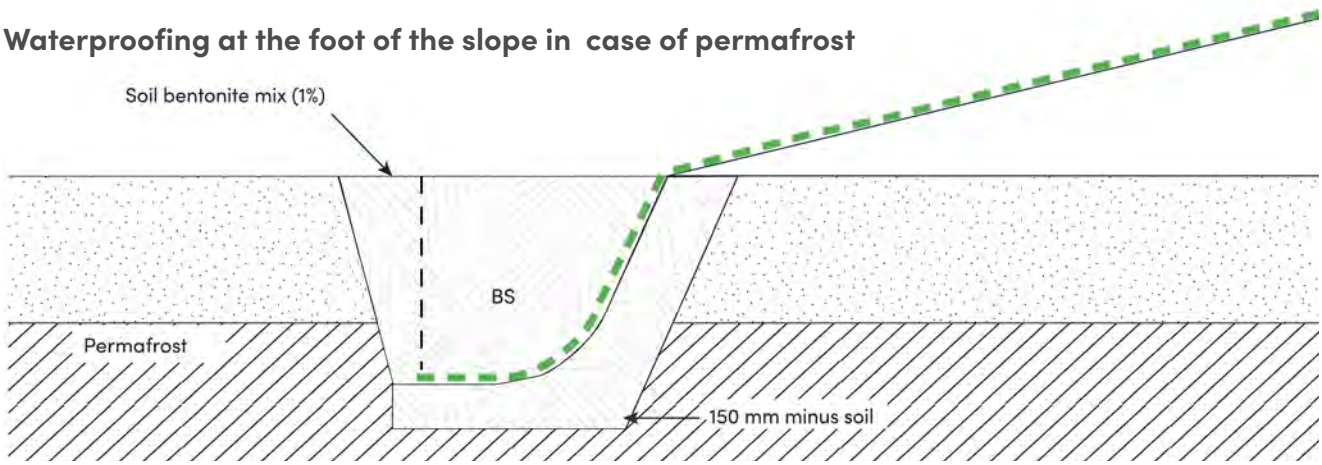
Care must be taken when compacting the clay, because this may cause wrinkling, especially when the Coletanche is hot (due to the sun). This can occur on the last layer of clay and propagates as the backfill is put in place.

The largest wrinkles (up to 0.15 m) may be crushed during the compacting operation. If this occurs, the wrinkles must be cut out and repaired using 0.5 m strips of Coletanche.

5.2.7. PERMAFROST

In cases of permafrost in the soil, it is important to provide a subgrade material to protect Coletanche.

Waterproofing at the foot of the slope in case of permafrost



5.3. SEAMS

5.3.1. WELDING CREW

A typical manual welding crew includes:

- A welder;
- A helper for rolling;
- Possibly an additional worker if needed for seam preparation (clear dirty membranes exposed to mud or wind, etc.).

The welder leads the whole operation, setting the pace and directing the helper.

For safety reasons, even if only a few strips are involved, a welder must never operate alone on a site.

▲ Gold Mine, Tasmania

5.3.2. WELDING EQUIPMENT

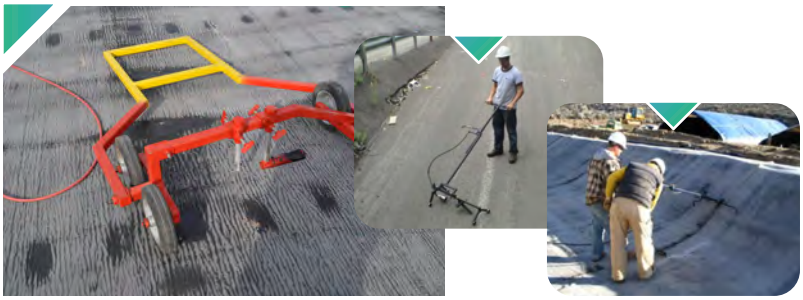
The equipment required for manual welding includes:

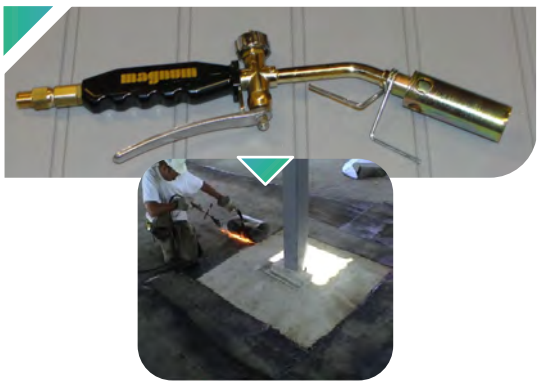
- Propane gas torch with a 4-hole flat burner, attached with a lance and a trigger handle with adjustable flow;
- Propane gas bottles of 13 or 30 kg (29 or 66 lbs), with a hand truck and an adjustable pressure valve between 0 and 3 bars;
- Flexible gas feed pipe that is long enough to allow welding of a whole strip without having to move the propane gas bottle;
- Heatproof gloves in accordance with regulations;
- Small trowel;
- Fire extinguisher with powder or carbon dioxide.

The torches well fitted to this kind of application are:

- Gas torch;
- Lance;
- Handle;
- Pressure regulator with safety valve, pre-adjusted between 0 and 3 bars;
- Pressure regulator with pressure meter, adjustable between 0 and 3 bars.

WELDING EQUIPMENT AND USAGE





5.3.3. ROLLING

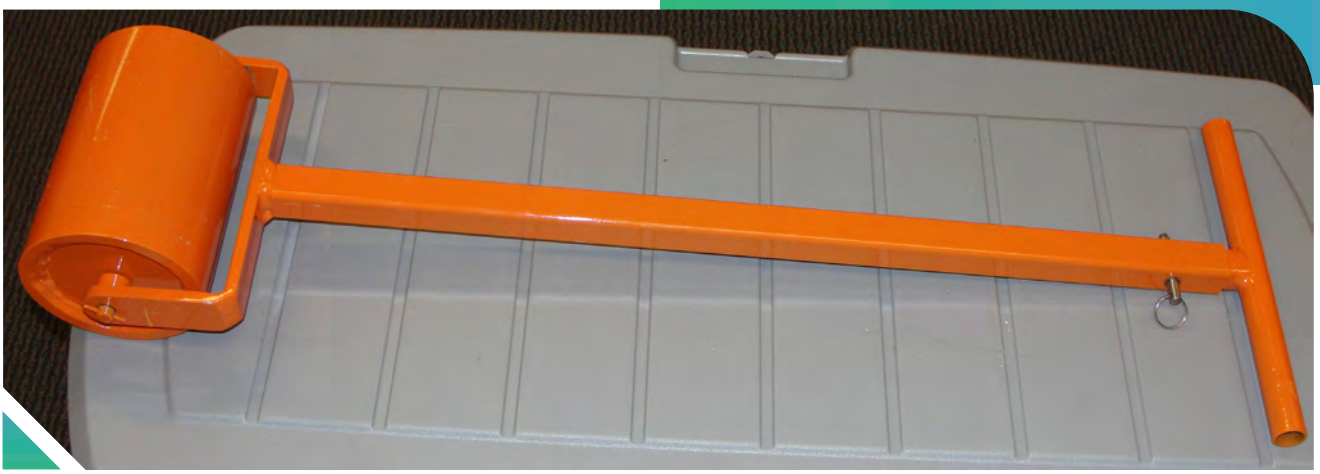
To roll the seams, the following equipment must be supplied:

- A 10 to 15 kg (22 to 33lbs) metal roller, of 20 cm (8in) wide , to be used on flat surfaces;
- A 5 kg roller for the slopes and details;
- A bowl of wet rags, possibly mounted on a shaft (mop) for details;
- A bucket of water;
- A scraper to remove bitumen runoffs that may accumulate on the rollers.

The geomembrane must be rolled along the seam. A slight angle from the center to the edge can be applied to remove:

- Trapped air;
- Excess bitumen from under the geomembrane.

DO NOT hold roller too close to the flame.



▲ Roller

5.3.4. CONSUMPTION

There are two types of propane gas tanks:

Vapor gas tanks

It draws vapor from the top of the tank with a short stem inside the tank.

The vapor has a female fitting on the on/off valve requiring a male fitting on the regulator.

To torch with a vapor gas tank, you must use a vapor torch head.

The vapor gas tank is best for summer use at temperatures of -10°C/14°F and more.

The consumption for the vapor torch in summer is approximately 0.08 kg or 0.18 lbs per linear meter.

Liquid gas tank

It draws the liquid with a long stem to the bottom of the tank.

To torch with a liquid gas tank, you must use a liquid burner head.

The liquid tank has a male fitting on the on/off valve requiring a female fitting on the regulator.

The liquid gas tank is best for winter use at temperatures of -10°C/14°F to –35°C/–31°.

The consumption for the liquid burner is approximately 0.05 kg or 0.18 lbs per linear meter.

SAFETY

- In winter, to eliminate the LPG tanks from freezing up due to the great demand of gas during use, it can be placed in a tub with a mixture of plumbing antifreeze;
- In summer, only place tanks (LPG) in a basin of water to prevent it from freezing;
- In both cases, you only need to place the tank in a minimum height of 12” or 30 cm of liquid.

HANDLING

- The use of mop buggies, the type that roofers use for mopping down asphalt is a very good tub to use;
- This tub has wheels and a handle to pull along with the LPG tank sitting in the liquid;
- Be sure to secure all LPG tanks, as a preventative measure from falling over.

5.3.5. WEATHER CONDITIONS FOR WELDING

The outdoor temperature during welding operations may be between -35 °C to 40 °C (-31 °F to 104 °F).

The wind must be moderate, otherwise it becomes difficult to control the proper temperature of the two faces to be welded, and the flame would tend to move above the upper geomembrane, which will then hinder the rolling of the seam.

Moisture should be removed prior to welding.

The presence of water is strictly forbidden, as it vaporizes to the contact of hot bitumen and creates bubbles that will remain within the seam.

Slight moisture can disappear with the flame.

5.3.6. TECHNICAL DETAILS

CLEANLINESS OF WELD

The surface to be welded must be clean to ensure no defects and a proper mechanical resistance in accordance with specifications.

Visible mud traces must be cleaned with a sponge.

Any sharp stones that may still lie under the lower geomembrane must be removed, as their presence would hinder the proper rolling of the seam.

REMOVAL OF TERPHANE

When welding specific areas such as cross cuts, the terphane film under the upper geomembrane must be carefully removed. As the melting temperature of the terphane is similar to that of the weld area, it is rarely correctly removed during the welding process, which will hinder the long-term behavior of the seam.

It is therefore necessary to burn it in advance, after turning the geomembrane upside down

5.3.7. DETAILED PROCEDURE

CLEANING

Cleaning operations must be carried out carefully in the following way:

- The assistant welder lifts up the top geomembrane and removes the PE silicone film after the area has been cleaned;
- Using a broom, carefully remove any sediments (sand, soil, fine gravel, etc.) from the area to be welded.

WELDING

The procedure for welding is as follows:

- Remove any sharp stones that may still lie under the membrane, as their presence would hinder the proper rolling of the seam;
- Carefully brush the seam area to remove loose sand.
- Clean mud traces with a sponge;
- Remove the PE silicone film after the seam area has been cleaned;
- Carefully burn in advance the terphane film where present, after turning the membrane upside down;
- First, weld a 50cm (1.6 ft) long area, and roll the roller on it carefully to join the two strips together;
- While moving at a continuous steady pace with one hand or a hook, lift the upper membrane about 10cm (4 inch) and insert the torch between the two strips, while keeping the flame aligned with the edge in order to heat the 20cm (8 inch) width in one single run;
- Carry out the rolling 1.5 or 2.0 meters (5 or 6.6 ft) behind the burner, about 1.0 meter (3.3 ft) behind the flame;
- The torch must be tilted so as to simultaneously melt the bitumen on both surfaces;
- The welder heats the overlapping surfaces until the bitumen begins to melt (stop before the bitumen melts completely or begins smoking);
- The entire width of the overlap must be welded;
- The welder lowers the top geomembrane onto the bottom geomembrane, which may leave a few wrinkles in the overlap.

Attention!

It is essential to carefully verify whether the two geomembranes are perfectly welded together.

▲ Torch head between the two strips

▲ Bitumen overflow

ROLLING

Immediately after the welding operation, the assistant welder presses down on the overlap with a roller, making sure the wrinkles are removed.

A roller weighing at least 10 kg must be used on horizontal surfaces, and a 5 kg roller on slopes.

As an alternative to a rounded trowel, a moist cloth can be used (by waterproofers) in tight corners, taking care not to leave any marks.

Rolling is then carried out between 1.5 and 2 m (5 and 6.6 ft) behind the burner, i.e. about 1 m (3 ft) behind the flame.

Roll vigorously to get a good contact between the two sides.

Do NOT step on a hot seam, as footprints will remain on the soft bitumen.

BITUMEN FLOW

A bitumen bead must flow when rolling over the seam. This is visual proof of good quality weld.

A larger bitumen flow shows an overheated weak seam.

If no liquid flow appears, then the bitumen did not melt enough.

The roller should not be applied on the bitumen edge; otherwise it will be contaminated, and stick to the upper surface of the geomembrane.

FINISHING THE WELD

The welder then adjusts his forward speed and the torch power to control the amount of heat applied to the seam.

Once the strip is finished, cooled down and visually inspected, the welder proceeds to the finishing works, through reheating the edge and shaping it as a filet, with a small rounded trowel.

WELDING DIRECTION

For flat surfaces, the welding direction is up to the welder, and mainly depends on being right- or left-handed.

For slopes, welding must be carried out upwards, so that the melted bitumen always creates an edge which the roller pushes upwards, and the bitumen seam does not get too lean.

▲ Finishing works with a gas burner and a trowel

5.3.8. VARIANT TO TORCH WELDING: HOT AIR WELDING

INTRODUCTION

The technology for welding bituminous layers using electrically powered hot air has been in use for many years. After a long period of testing and investigation, hot air welding was introduced to bituminous geomembrane installations. The main motivation for using hot air to weld bituminous geomembranes is to negate the use of an open flame. This is important in situations where flammable gas or other flammable materials are potentially present. There are a number of other potential benefits that can be gained from implementing hot air welding on a bituminous geomembrane project:

- Improved quality assurance by controlling welding temperature and welding speeds;
- Less labour or effort required as the hot air welder applies heat and roller pressure with motorised propulsion;
- More efficient use of energy with the heat directed in a targeted weld area;
- A higher level of safety for operators.

EQUIPMENT

Various types of hot air welding equipment have been trialled and tested. The best overall performing equipment was found to be made by Leister. For a bituminous geomembrane project, important considerations for selection of hot air welder equipment include:

- Availability of local servicing and equipment maintenance;
- Availability of replacement parts such as the heating element;
- Reputation of the manufacturer;
- Appropriate generator, extension cable and cable connections. It is critical to equip the welder with compatible extension cables and generators considering Voltage, Amperage, Phase, and pin setup (i.e. 4 pin vs 5 pin).

BITUMAT B2

The Bitumat B2 is a hot air welder designed specifically for welding bituminous membranes. Its operation allows for the user to control speed, temperature, fan speed, roller pressure, and blade width.

▲ Profile of hot air welding schematic featuring the hot air nozzle in red and air dam in green.

ELECTRON

For patches and detailed welding work a handheld hot air welder is necessary. It is advisable to favour a high powered version of this equipment such as the Electron made by Leister. This tool can be accessorised with various narrow width nozzles.

ROUNDED TROWEL

To perform the fillet weld, the rounded trowel is used in a similar manner as with torch welding. It can be more efficient to complete the fillet weld while the bitumen bead from the hot air welder is still hot; however this method means that the air lance leak detection method can only be performed after both welding actions.

HOT AIR WELDING PROCESS

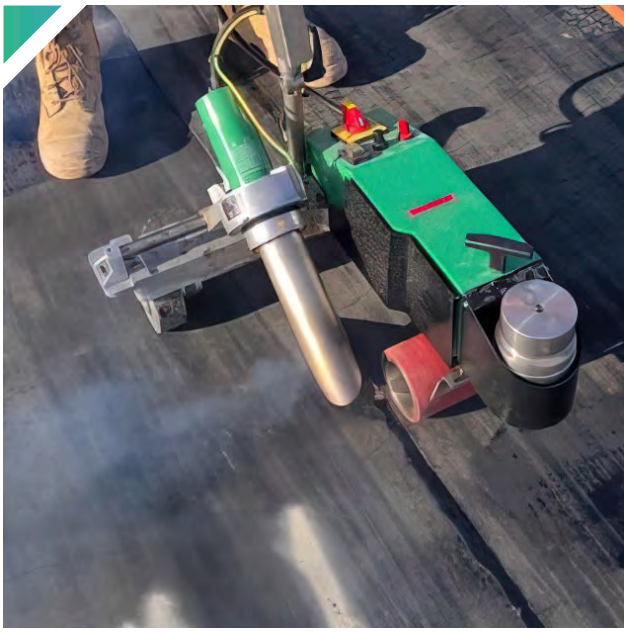
The process for deploying Coletanche is the same for hot air welding as it is for torch welding. The panels should be overlapped by a minimum of 200mm as indicated by the green line on the edge overlap. The peel away release paper can be used to reveal a clean weld area just before the hot air welder approaches. If the release paper is not present, the weld can be made by melting away the terphane film. In both cases, the welder temperature and speed should be tuned so that a visual bead of bitumen extrudes out of the weld as the roller passes over it as seen in the figure below. Typically, a target minimum of 5mm bead width should be observed. The liner temperature can affect the welder settings. In most conditions, the Bitumat B2 can be set at the max temperature and max fan speed with the speed tuned up or down to create the target bitumen bead. To observe a sufficient bead width, it is important that the operator tracks the roller within approximately 1cm of the overlap edge. Too close to the edge may contaminate the roller with hot bitumen while too far from the edge will not extrude enough bitumen to expose a bead.

OPTIMISING WELD STRENGTH

The appropriate equipment should achieve a hydraulic seal indicated by the bitumen bead as well as the minimum weld strength from the design specifications. A minimum weld strength of 80% of the minimum cross machine direction parent material shear strength is recommended. In addition to the drive speed, temperature, and fan speed, there are welder features which can be adjusted to increase weld strength.

- Hot air welder manufacturers offer various nozzle widths ranging from 80mm to 130mm. In general, wider welds can achieve stronger welds as long as sufficient heat is applied.

- Welders also allow for the roller pressure to be adjusted by changing the applied weight which sits above the roller;
- The distance of the nozzle to the roller can be adjusted on some welders;
- An additional process of manually rolling a weighted roller can be applied to the weld after the welder has passed.



▲ Bitumate B2 welding with optimal bitumen bead extrusion

▲ Fillet weld demonstration using the Electron handheld welder and a rounded trowel

PATCHING

The handheld hot air welders can be used for patches.

5.3.9. VARIANT TO WELDING: BONDING

Instead of welding, Coletanche seams can sometimes be bonded:

- When working under water or in presence of water (canals);
- When connecting the Coletanche geomembrane to other types of geomembrane which do not stand the heat of the gas burner (HDPE, PVC-P, PP-F);
- When connecting the geomembrane to metal or concrete pipes.

▲ Bonding on concrete footings

▲ Bonding on concrete footings

Bonding is carried out with a bituminous mastic, such as Bitumseal as manufactured by Coletanche or a similar product. This product can be applied to a trowel from a caulking gun and with a spreader with a heated nozzle.

The quantity of bituminous mastic required is 2 kg/m^2.

Suitable for use at temperatures between 5°C and 35°C, the bituminous mastic is applied directly on to a cold, clean surface free from dirt and grease. Strings of Bitumseal are applied with a manual or pneumatic applicator and smoothed over with a spatula. Bitumseal can be applied over moist surfaces, underwater and in rain. In these situations, remove as much water as possible with the plastic nozzle of the applicator which must be in direct contact with the surface to be treated before applying the mastic (a trial is recommended prior to application). Use of a backer rod is recommended in the joint when possible to allow Bitumseal to form the best seal

Bitumseal dries without shrinking and forms a smooth, flexible skin. Full adhesion is reached when fully dry (at least 4 weeks) and the bond depends on the nature of the surface and the sealing method. Immediately after application the glue will have sufficient adhesive power to handle small loads.

A pressure must be applied for a minimum period of four weeks with sand bags, boulders or concrete blocks.

Depending on the size and geometry of the pond, panels can be welded in the dry and then can be pulled using a barge in the pond and therefore limit the number of “bonded” seams. This can be done easily because the high density of Coletanche is 1.24.

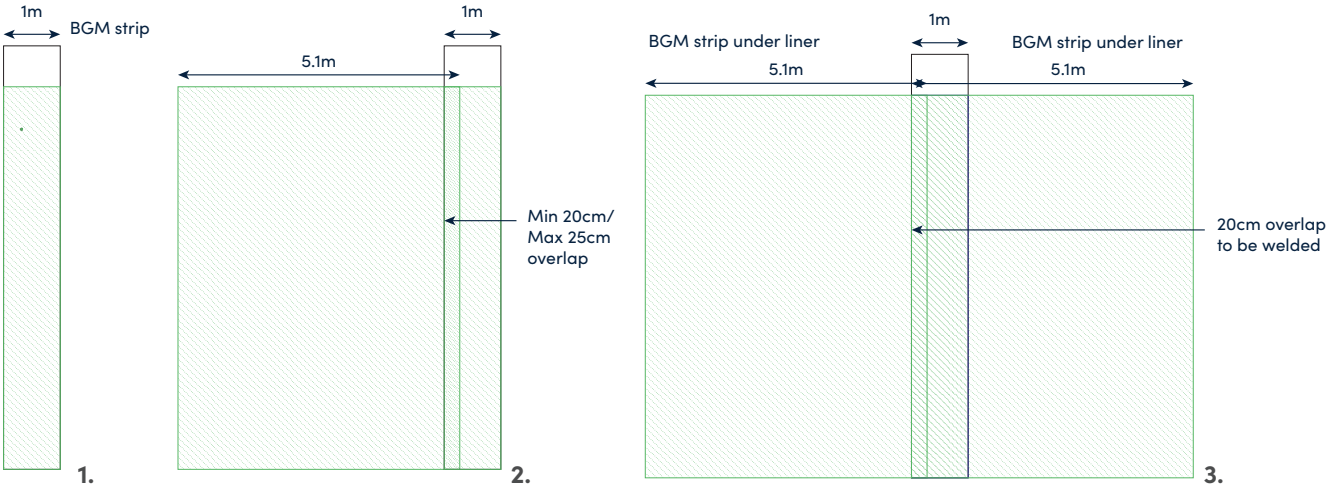
5.4. PROTECTION OF GEOTEXTILES AGAINST FLAME DAMAGE

A geotextile can be applied as a protective layer under the geomembrane and it must be protected against flame damage. If it is made of polypropylene, it may be damaged when welding by the heat of the flame and melted by the bitumen run off. The damaged surfaces are generally very small, but nevertheless it may be advisable to lay a thermal protection between the geotextile and the geomembrane.

1m (3.3 ft) wide strips of bituminous geomembrane roofing products or Coletanche can be used.

The diagram below shows the procedure for welding Coletanche over flammable membranes or geotextiles.

Protection of geotextiles against flame damage



1. Place 1m BGM strip over flammable membrane or geotextile

2. Place 5.1m Coletanche roll over the 1m BGM strip with a min 20cm and max 25cm overlap

3. Place the subsequent 5.1m Coletanche roll over the 1m BGM strip with the 20cm overlap to be welded (As per the standard Coletanche Installation)

5.5. CONNECTION TO VARIOUS SURFACES

An entire structure can be evenly waterproofed by welding Coletanche to concrete, steel, PVC, and HDPE surfaces.

A few simple rules to ensure a perfect weld:

- Plan to limit settling to the right of anchoring structure and of the subgrade (most waterproofing defects at overlaps are caused by settling of uncompressed backfill near the structure);
- Remove any sharp edges that may come in contact with the Coletanche geomembrane (smooth surface finishing of concrete);
- Make sure there are no voids between the geomembrane and the support;
- Avoid wrinkles in the geomembrane and sharp angles;
- Work on dry concrete. The structure must be completed at least three weeks before applying the Coletanche geomembrane.

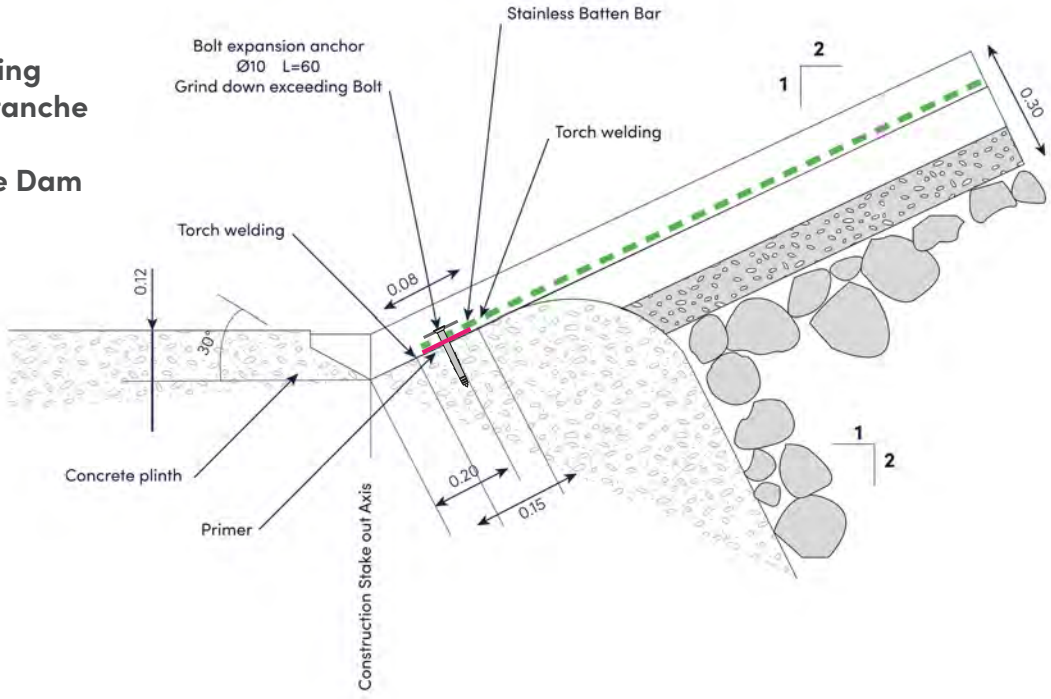
5.5.1. CONNECTION TO CONCRETE STRUCTURES

GENERAL POINTS – WELDING - BONDING

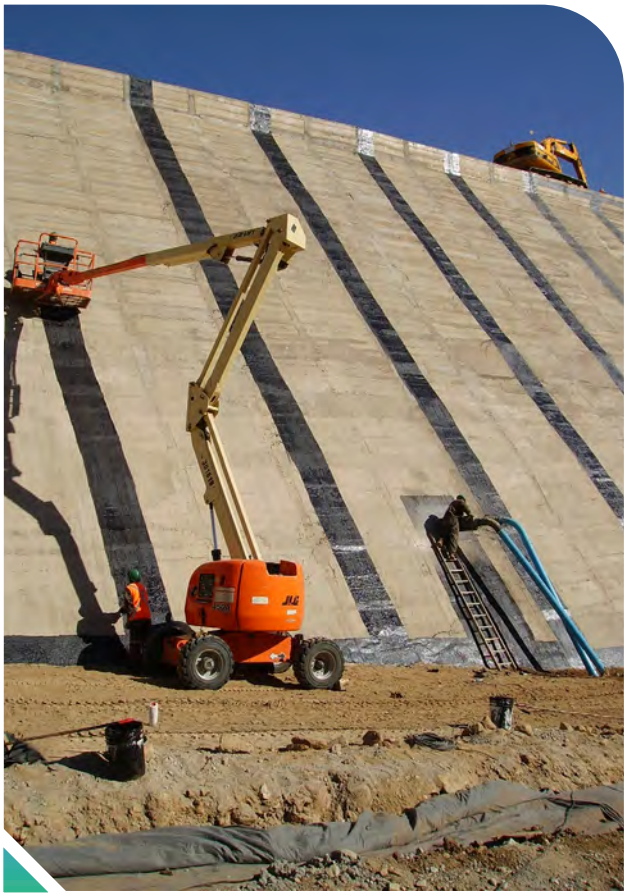
Connection to other structures is generally the most delicate part of a project.

Such connection works must be dealt with as early as the design phase, with the recommended use of rounded shapes.

Detail of bonding between Coletanche and Concrete for La Galaube Dam

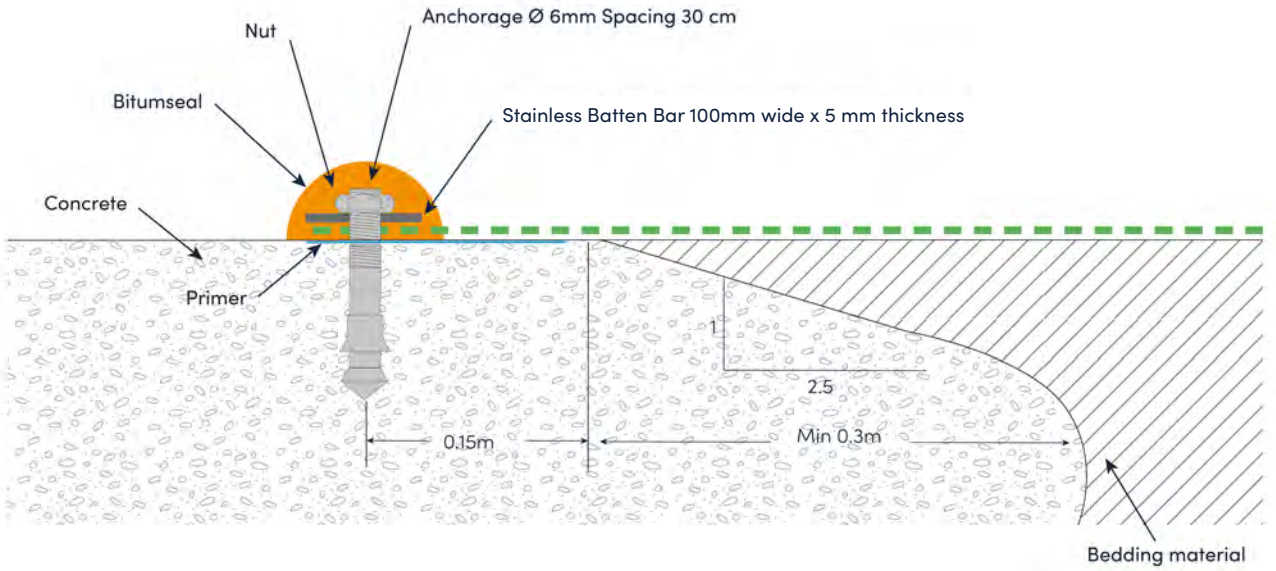


▼ Unacceptable concrete surfaces that would need major renovations



▲ Acceptable surface - El Mauro Dam (Chile) – Slope 0.7/1

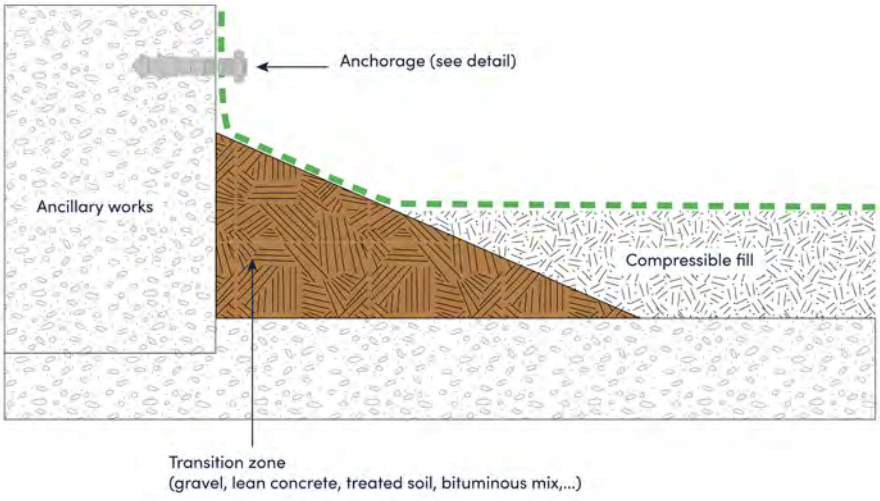
Anchorage Detail on Concrete Surface



Special attention must be paid by the site manager.

Backfill compaction around those specific points must be carefully carried out, with adequate equipment, in order to minimize the differential settlement.

Limitation of differential settlement in the transition zones to the ancillary works (principle diagram)

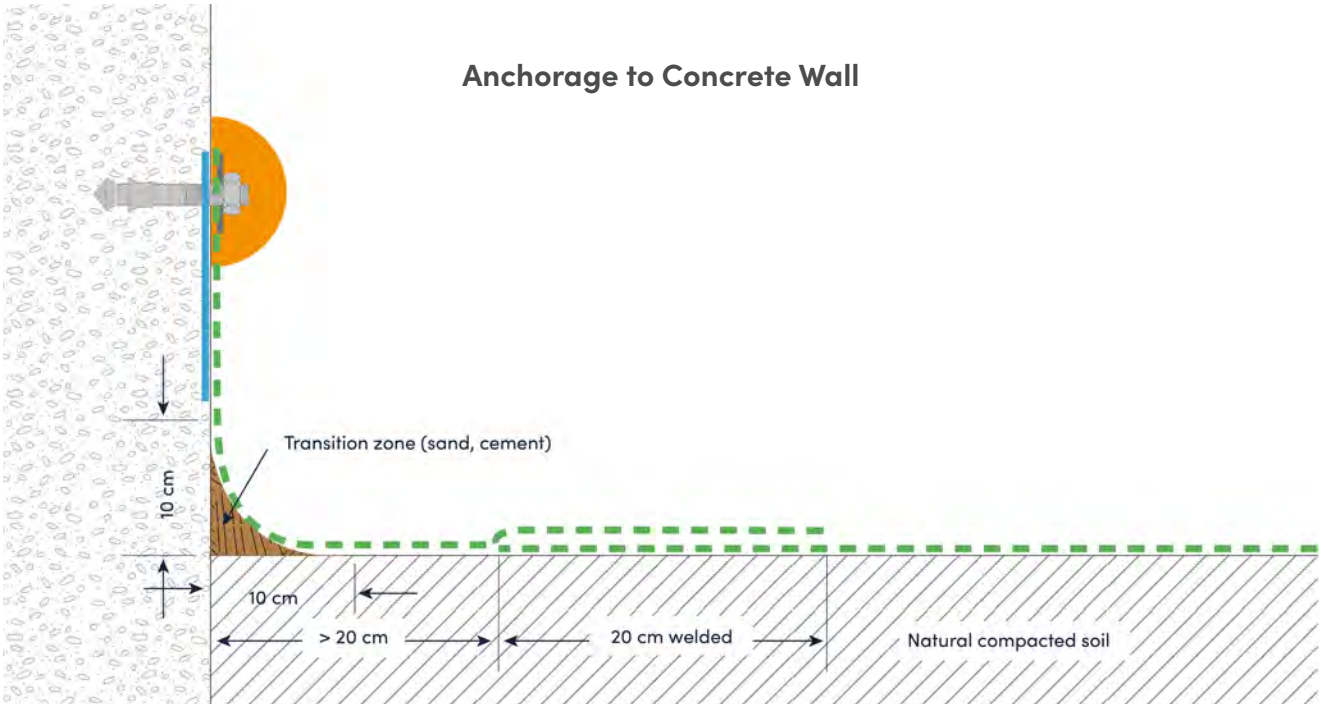


▲ Welding on steel

▲ Bonding to pipe and manhole

Good construction procedures, as detailed below, may reduce the consequences of possible settlements, and make them compatible with Coletanche elongation properties.

Anchorage to Concrete Wall

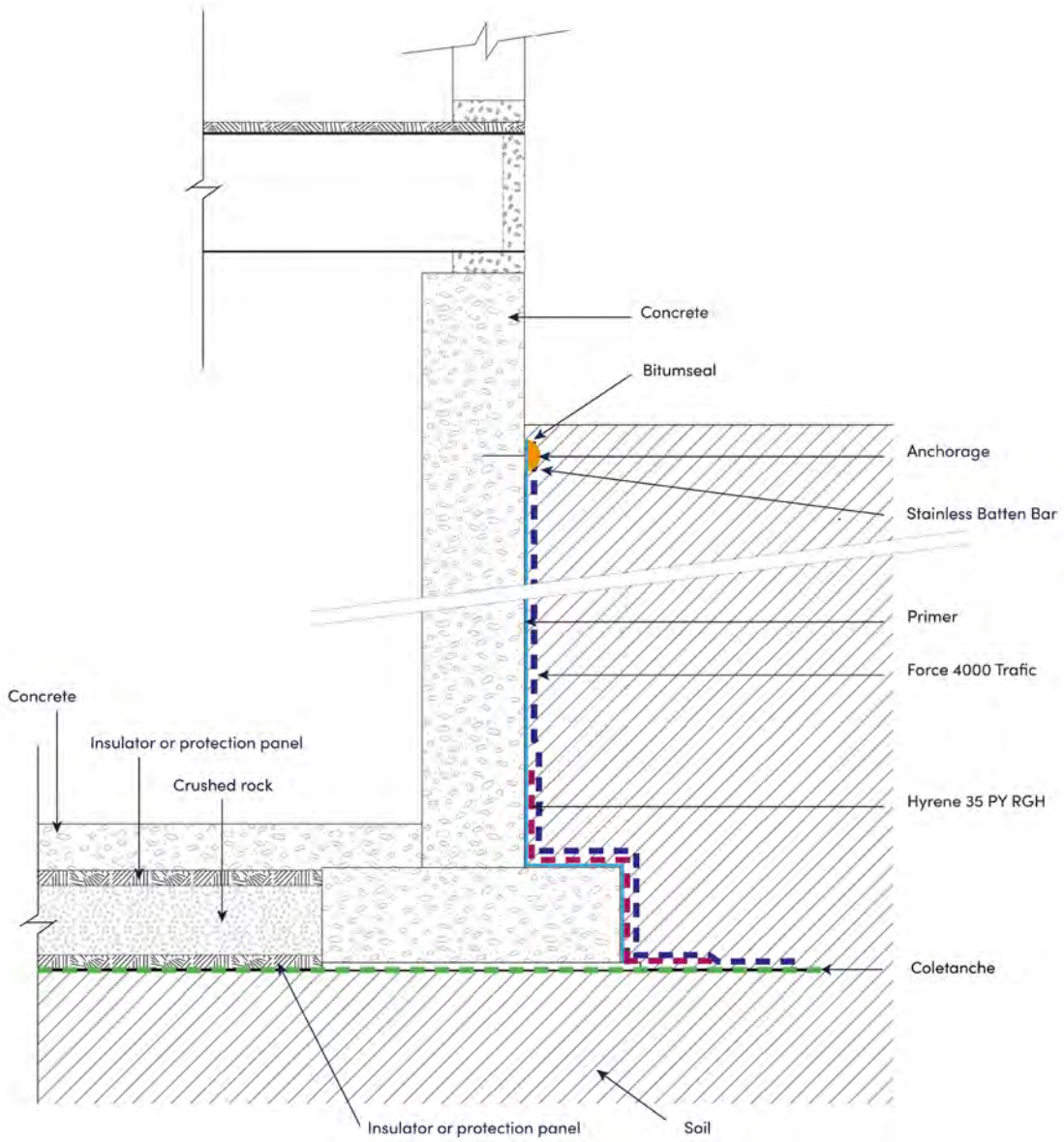


PROCEDURE

The connection between the Coletanche bituminous geomembrane to concrete shall be carried out according to the following general procedure:

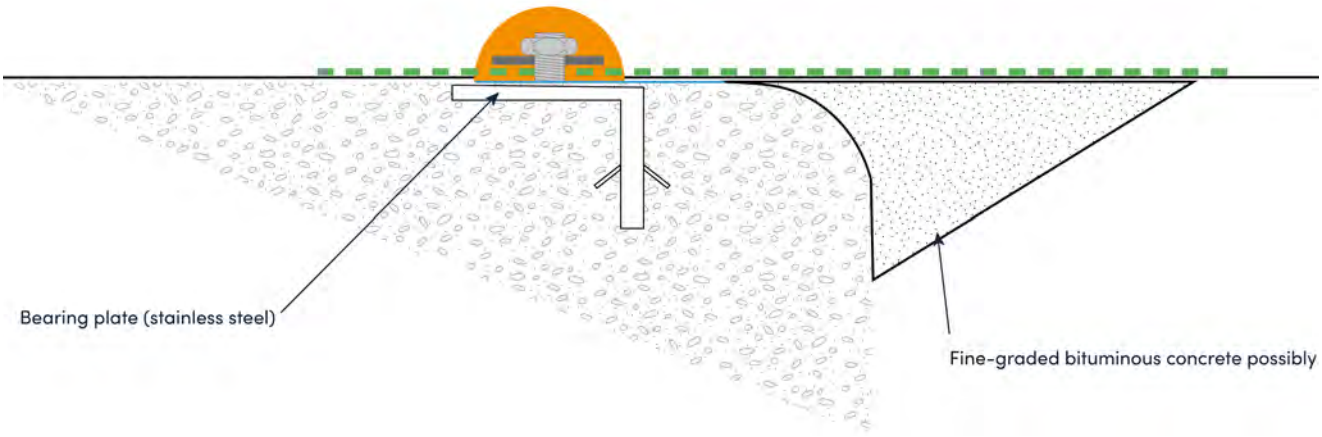
- Ensure concrete is dry before placing primer (usually 21 days);
- Apply a bituminous primer with a brush over the dry concrete where the liner is previewed to be placed.
- After the primer is dry (usually after 60 minutes at 25°C), put the liner in place;
- With a flame torch, heat the primer and the liner at the same time and roll with a small roller applying high pressure to ensure that they are both sticking together. Bitumen will leak and fill the small voids on the surface of the concrete;
- Spread excess bitumen with a trowel;
- Compress the corner to where the liner is bent on the connection of the wall to the ground to make sure the liner is well attached;
- Place 100 mm wide x 5 mm thick stainless batten bars on the edge if where the liner is placed;
- Drill holes in the batten bars to locate where the 6 mm anchor bolts will be placed at 250 mm spacing c/c;
- Install and tighten anchors with a nut;
- Apply mastic at the edge of the batten bar and the concrete to ensure attachment.

Waterproofing under slab and foundation wall



A plate made of stainless steel (batten bar), aluminum or plastic can be applied through bolting or tacking into the concrete, in order to increase the connection durability. Cut the geomembrane exceeding the plate. This fixation may then be protected either by an additional Coletanche strip, or through a bituminous binder cover (such as Bitumseal).

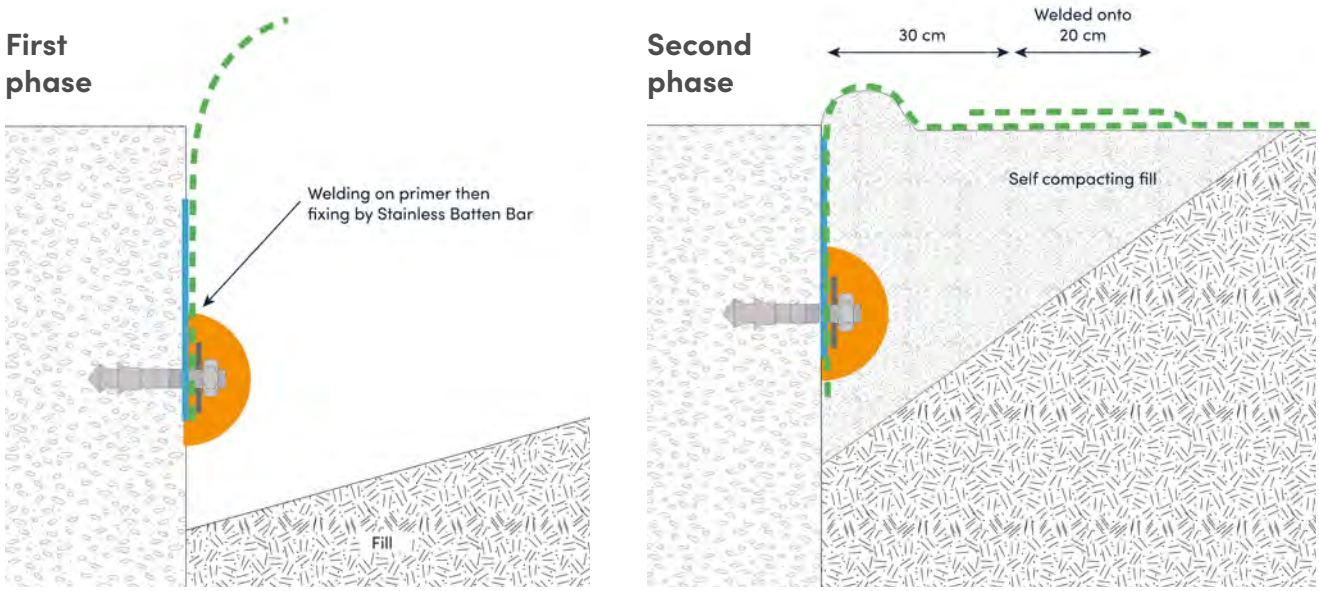
Connection at a concrete work



EXAMPLES

▲ Connection to a concrete block: torching on primed wall and applying mastic

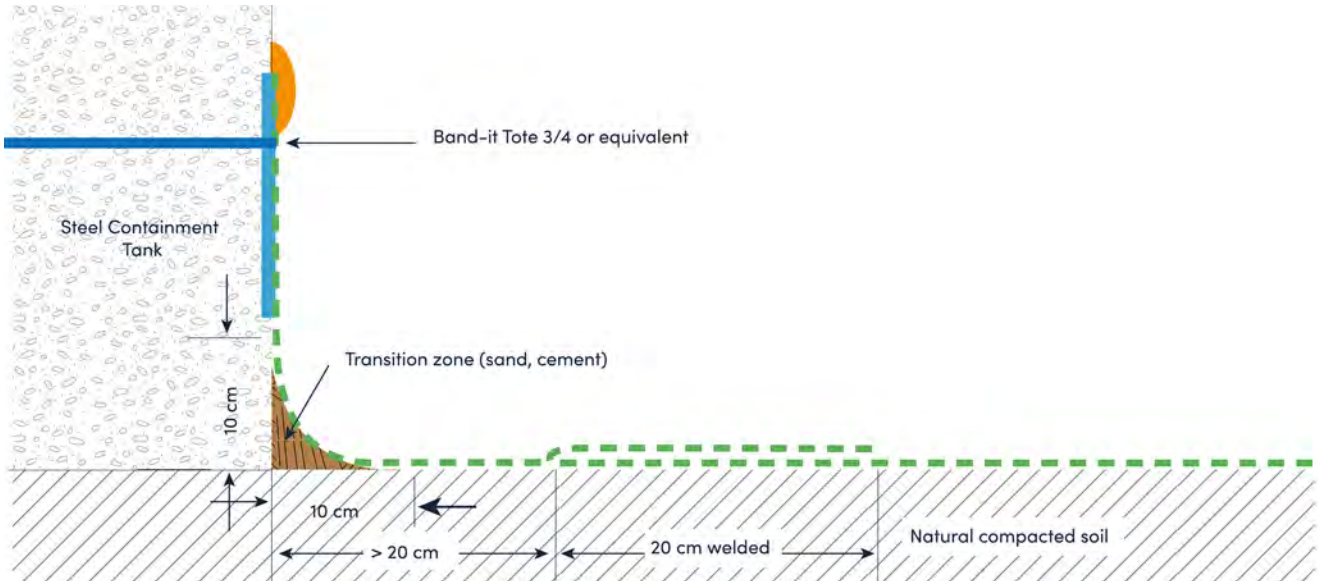
Connection to a concrete block - Buried geomembrane



5.5.2. CONNECTION TO STEEL

In some cases, such as for a steel containment tank, the bonding between the Coletanche bituminous geomembrane to steel needs to take place without piercing the steel. The general procedure would be carried out as such:

- Make sure there is no excess rust on the steel surface to be welded. If so, clean the rusted surface;
- Apply a bituminous primer with a brush over the steel where the liner is previewed to be placed;
- For application rate (usually from 150 to 350 g/m^2), consult the Primer data sheet;
- After the primer is dry, put the liner in place;
- With a flame torch, heat the primer and the liner at the same time to ensure that they are both sticking together. Bitumen will leak;
- Spread excess bitumen with a trowel;
- Compress the corner to where the liner is bent on the connection of the wall to the ground to make sure the liner is well attached;
- Apply a bituminous mastic on the edge of the steel membrane and to ensure the fixing;
- Position the clamping ring around the perimeter of the tank and make sure it is tight;
- Attach the clamp ring with buckles.



5.5.3. CONNECTIONS TO WATER INLETS AND OUTLETS

GENERAL POINTS

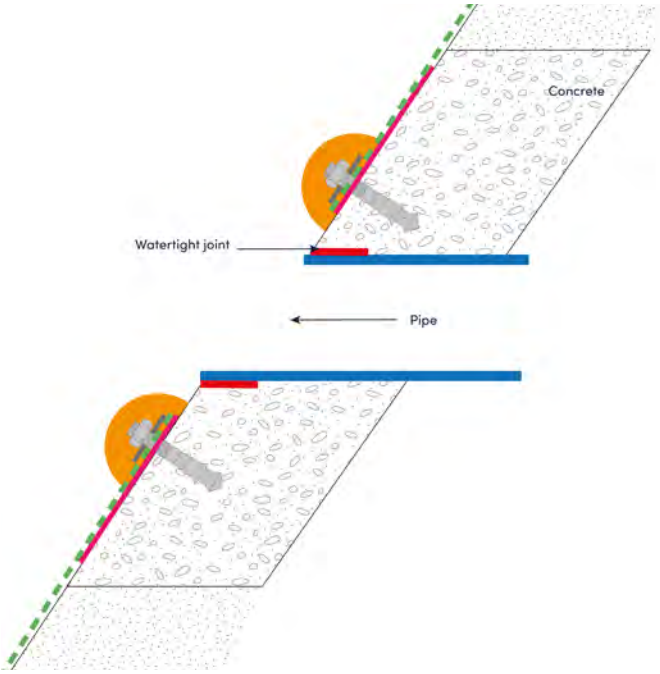
The same precautions must be taken when connecting the geomembrane to inlet or outlet pipes.

It is strongly advised to cast a small concrete block around the head of the pipe so as to connect the main layer of the geomembrane, and ensure the stability of the pipe.

Waterproofing around the pipe is ensured either through a Coletanche coupling sleeve on the pipe, through welding or with bituminous mastic such as Bitumseal (IKO-Axter) or an equivalent depending on the pipe resistance to flame. This connection may then be reinforced using a clamp collar.

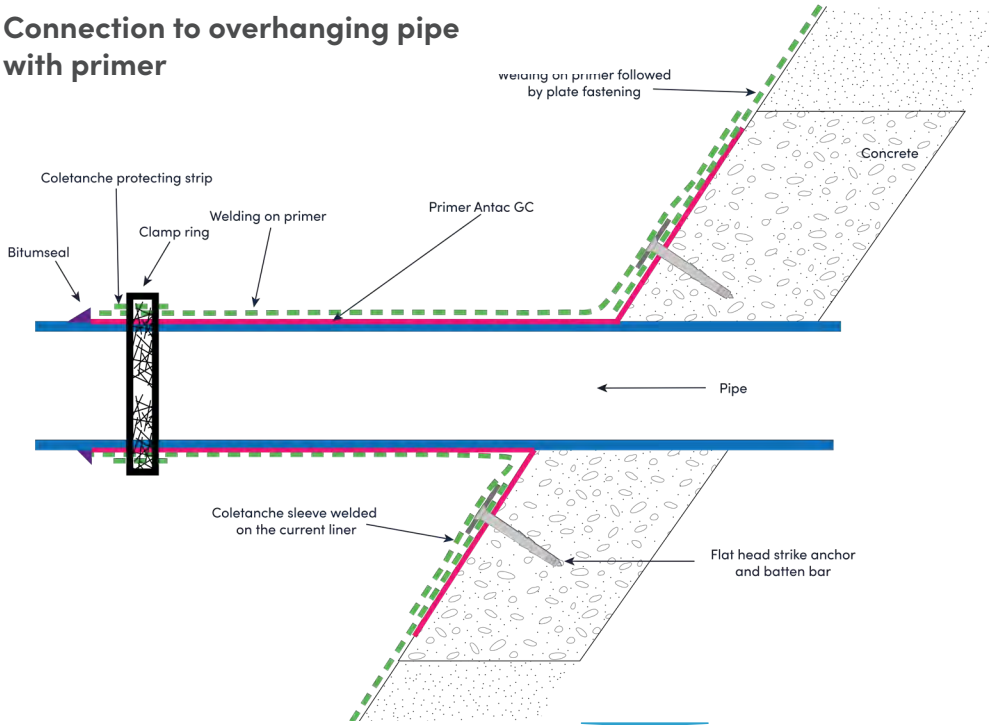
EXAMPLES

Connection to a pipe showing on the surface or corrugated pipes



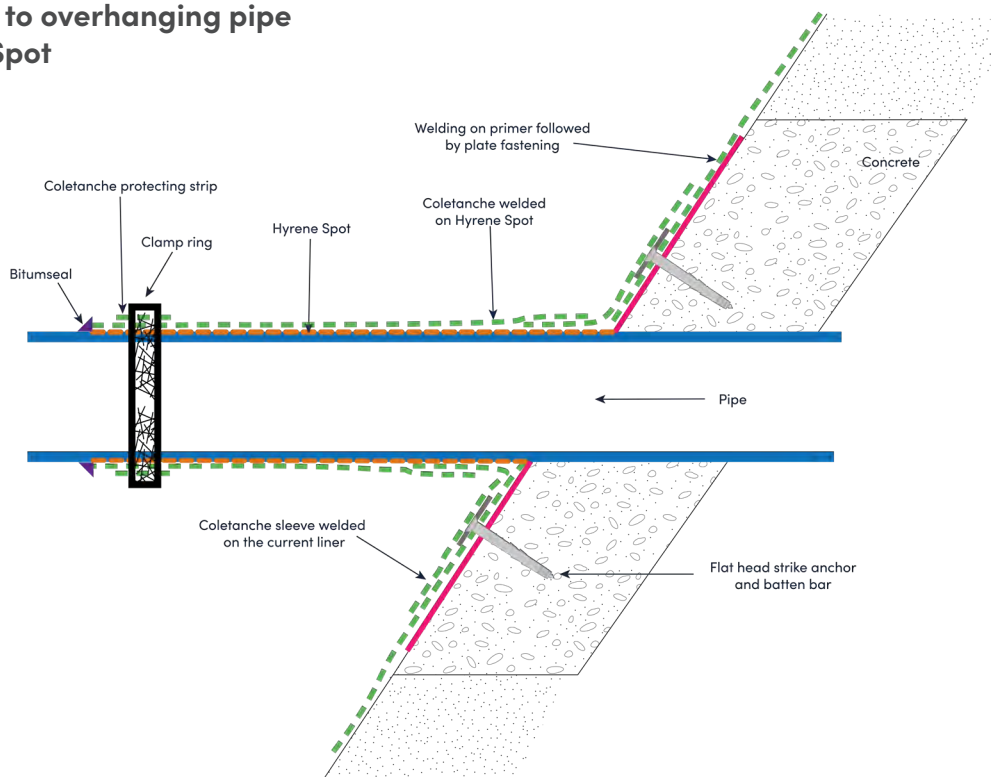
▲ Connection to overhanging pipes

Connection to overhanging pipe with primer

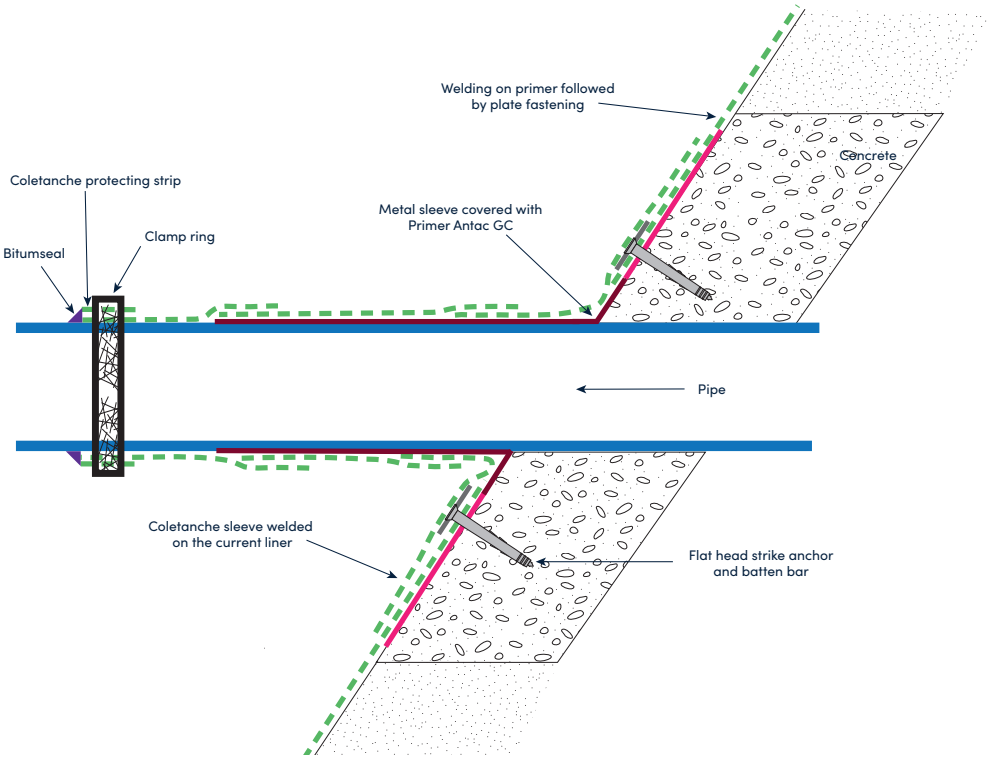


▲ Concrete block and primer coating around a concrete pipe

Connection to overhanging pipe on Hyrene Spot



Connection to overhanging pipe on metal sleeve



5.6. ENVIRONMENTAL PROTECTION - WASTE MANAGEMENT

The Coletanche plant is ISO 14000 certified.
Environmental protection applies when the geomembrane is being installed.

5.6.1. COLETANCHE OFFCUTS

Coletanche offcuts and possible surplus of material which cannot be used as under-layer are considered as usual **industrial wastes** and can be sent to ordinary asphalt plant landfills.

They must be periodically collected and stored in a specific area before being sent to the landfill.

5.6.2. PE SILICONE FILM

The PE Silicone film protecting the welding strip must be collected and stored until being sent to the landfill.

It is possible to recycle these films, depending on the local regulations.

5.6.3. ADHESIVES & PRIMER COATINGS

Bins for primer of bonding agents must be collected and stored in a specific area, and sent to **a specialized industrial waste landfill.**

5.7. QUALITY CONTROL

Example of specifications, which includes all the standards related to Coletanche can be provided upon request. One can notice that there is a complete range of ASTM standards related to bituminous geomembrane (i.e. Coletanche) and also other international standards.

There are specific ASTM tests methods for seams for bituminous geomembranes.

ASTM D7700-Standard Guide for Selecting Test Methods for Geomembrane Seams provides a Table showing all the ASTM standards for the tests methods necessary to evaluate geomembrane seams, applicable to different geomembrane materials:

Seam Evaluation Techniques and their Applicability to different Geomembrane Materials		
Type of Seam Evaluation Technique	**ASTM Test Method / Type of Geomembrane**	**Bituminous Geomembranes (PBGM)**
Destructive	D6214/D6214M Field seams, chemical fusion methods	–
	D6392 Nonreinf GM-Seams Thermo-Fusion Meth	–
	D7408 PVC Seam	–
	D7056 BGM Seams	X
	D7272 Taped seams evaluation	–
	D7747 Reinforced GM, Strip Test	–
	D7749 Reinforced GM, Grab Test	–

Seam Evaluation Techniques and their Applicability to different Geomembrane Materials		
Type of Seam Evaluation Technique	**ASTM Test Method / Type of Geomembrane**	**Bituminous Geomembranes (PBGM)**
Non-Destructive	**D5641** Vacuum Chamber	X
	D4437 Air lance	X
	D4437 Mechanical point stressing	X
	D5820 Pressurized Air Channel	—
	D6365 Spark Test	X
	D7177 Air Channel Evaluation of PVC	—
	D7006 Ultrasonic Testing of Geomembranes	X
Electrical Leak Location	**D7002** Leak location/water puddle/lance	X
	D7007 Leak location/covered geomembranes	X
	D7953 Arc Test	X

X = Applicable — = Not Applicable

They are classified in destructive, non-destructive, and electrical leak location tests. There are as many standards for bituminous geomembrane as there are for other liners.

DESTRUCTIVE

Shear testing of the seams:

Tests is carried out in the field using a tensiometer with specific geotextile jaws and according to the standard ASTM D7056. A defined sample of the seam is required for the shear resistance test. The value at which the seam fails is recorded and logged in by the quality supervisor. The sampled areas are to be repaired by welding a patch of Coletanche.

We recommend a minimum of 80% of the parent material minimum tensile strength in the weakest direction.

If this test method is chosen, it is recommended to perform it for every 150 linear meters of liner seams.

NON-DESTRUCTIVE TESTING

Vacuum testing

The seams are checked using a vacuum bell. The test is performed using liquid soap as a leakage indicator. If bubbles appear under the bell, the seamed section must be repaired.

If this test method is chosen, it is recommended to perform it for every 100 linear meters of liner seams.

Air Lance Method

This test consists in check the sealing and quality of the weld. With an air lance of a jet of air is fed to the edge of the weld. If the weld is continuous and free of defects (air bubbles, dirt) the air will not detach the membrane. In the case of a defect, the air jet will detach the membrane. If there are any leaks, they will be located and repaired. Refer to ASTM D4437 section 4.2 for the test procedure.

If this test method is chosen, it is recommended to perform it on 100% of liner seams.

Mechanical point stressing

The test is carried out once the bitumen has cooled. The joint is tested with a round-tipped trowel to ensure that the weld is not separating. A special attention must be taken if there is no bitumen bleeding out from the seam. All defects are recorded by the site supervisor in a Data Sheet and clearly marked for repair.

If this test method is chosen, it is recommended to perform it on 100% of liner seams.

Ultra-sound testing

The seams are checked using an ultra-sound device. After a calibration test, the ultra-sound machine is placed on the joint with a sufficient quantity of coupling agent to make sure contact between the probe and the membrane is good. To control the seams, the probe must be carried out over the total width of the seam. The results are recorded by the site supervisor and in the case of a defect, additional tests along the same seam are required (in between the failed test and the nearest passed test – both sides).

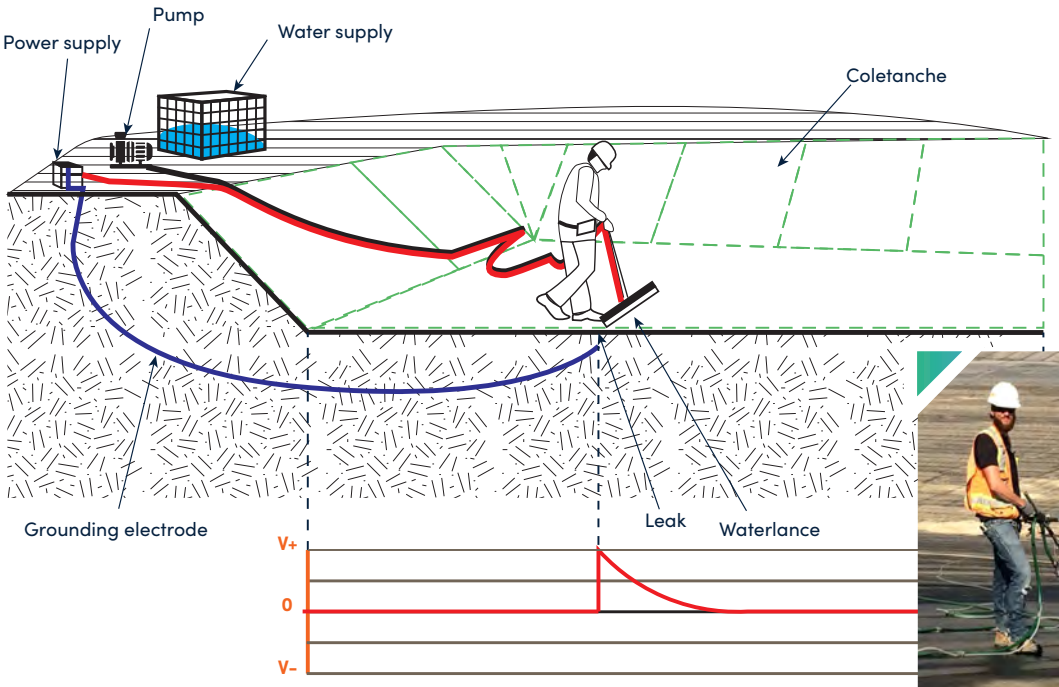
If this test method is chosen, it is recommended to perform it for every 150 linear meters of liner seams.

ELECTRICAL LEAK LOCATION

Water lance

Water lance method locates holes when geomembrane is exposed and dry.

Water Lance Method

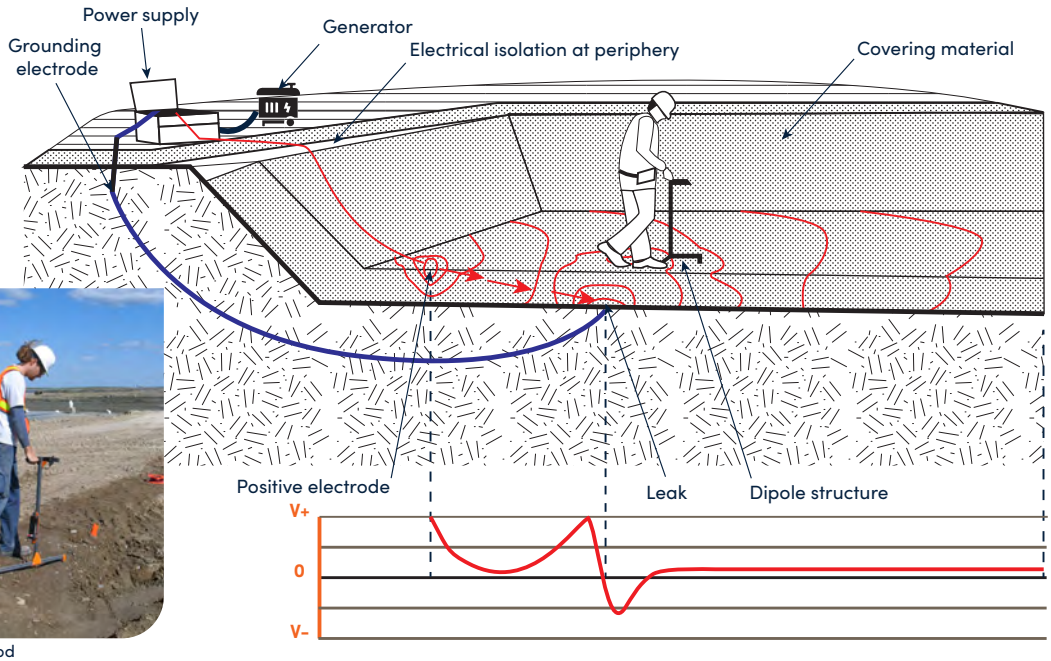


▲ Water Lance Method

Dipole method

It locates holes in the liner after it has been covered by water or soil.
Specialised workers are needed to complete these tests.
If this test method is chosen, it is recommended to perform it on 100% of the liner area.

Dipole Method



▲ Dipole Method

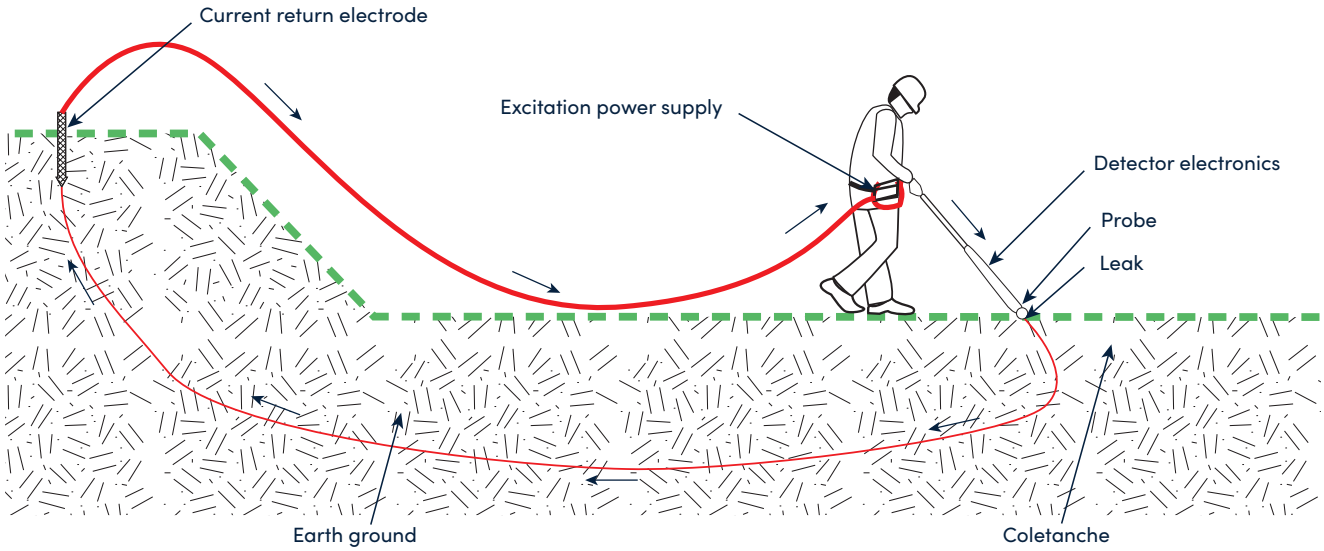
Arc testing

This test is performed according to ASTM D7953 - Standard Practice for Electrical Leak Location on Exposed Geomembrane Using the Arc Testing Method.

The principle of this electrical leak location method is to introduce a high voltage between a leak detection test probe and the conductive medium underneath the geomembrane. The area is then swept with a test probe to locate points where the current completes the circuit through a leak. A visible electrical arc is formed when the current completes the circuit and the current flow is also converted into an alarm (audible, visual or other, which confirms leak detection and location)

Testing must be performed on geomembrane liners that are generally clean and dry. Proper field preparations and other measures are implemented to ensure an electrical connection to the conductive material directly below the geomembrane liner to successfully complete the leak location survey. The arc test has limited ability to detect weld defects.

Electrical arc testing



5.8. PROCEDURE FOR SAMPLES

Please follow the following rules when you take samples to do the test.

- The sample must measure at least 200 mm (7.8 in) more than the width of the joint and the joint must be centered in the sample;
- The sample must be at least 100 mm (3.9 in) wide so that only one test can be made per sample, or at least 350 mm (13.78 in) if 5 tests must be carried out on the same sample;
- Each sample must be clearly identified with the machine direction.

Send the samples to an appropriate independent 3rd party laboratory.

5.9. REPAIRS

5.9.1. REPAIRS ON BAD QUALITY WELDS AND CREASES

Bad quality welds, non-conforming laps, serious creases and any other damage must be repaired with an additional layer of membrane. The patch dimensions must be at least 20cm (8 inch) larger on each side than the defect area as an overlap.

The patch is prepared with rounded edges. After carefully burning the terphane, the membrane must be welded on its whole surface. Quality control of seams must then be carried out.

A new membrane can easily be connected to an older one. On existing projects where the membrane has already been covered either by a protective layer, or by waste materials or mud, repairs to the membrane can be carried out in the same way, after carefully cleaning the membrane with high pressure water (50 to 120 bars).

5.9.2. WATERPROOFING HANDOVER PROCEDURE

Before covering the geomembrane with the protective layer (if any), the handover procedure for the waterproofing must be carried out, together with the client and the people in charge of the next stages.

It will consist of a site visit, together with an analysis of the tests carried out.

If repair works are requested, they have to be executed and accepted by the client before the next stage.

6. PROTECTIVE LAYER

6.1. COVERING

6.1.1. WHEN TO CONSIDER COVERING

Due to its mechanical behavior properties, the Coletanche geomembrane can resist weathering degradation without specific protection (UV), it may be subject to deteriorations that may appear both during the construction and the operation stages. This may be caused by:

- Driving with tracks or tires with a pressure above the ground bearing capacity (ex: for cleaning ponds);
- Contact with boats keels or anchors;
- Impact of floating bodies such as trunks, branches or other materials in suspension;
- Turbulence generated by a strong flow in a canal or by mechanical movements (agitators in liquid waste storage ponds), that can lead to seams opening under cavitation effects;
- Livestock trampling, when the pond is likely to be used as a watering place;
- Vandalism;
- Ice layer on the surface, which sticks to the geomembrane. This weight might create tensions in the geomembrane in the case of a water level drop, detached blocks which may tear the geomembrane.

NOTE: Taking into account the robustness of the bituminous geomembrane, lower quality materials, found locally, can be used for cost savings.

6.1.2. SPECIFIC PRECAUTIONS

Installing a protective layer on Coletanche does not create any problems, provided the following points are carefully followed:

- Adaptation of the protective layer to the structure and its future use (risk of erosion, settlements, and puncture by the protective layer);
- Stability of the protective layer on the geomembrane (risk of sliding of the protective layer, risk of tension inside the geomembrane under the weight of the protective layer) foot abutment;
- Install the protective layer with adequate equipment.

If the bearing capacity of the sub-base allows it, traffic, even heavy (finishers, supply trucks), can be temporarily allowed, provided no shear is generated inside the geomembrane (displacement).

Nevertheless, in most cases, it is best to lay the protective layer with an excavator from outside the structure (from the crest) or to place it with a small loader or bulldozer.

6.1.3. OVERVIEW OF THE DIFFERENT TECHNIQUES

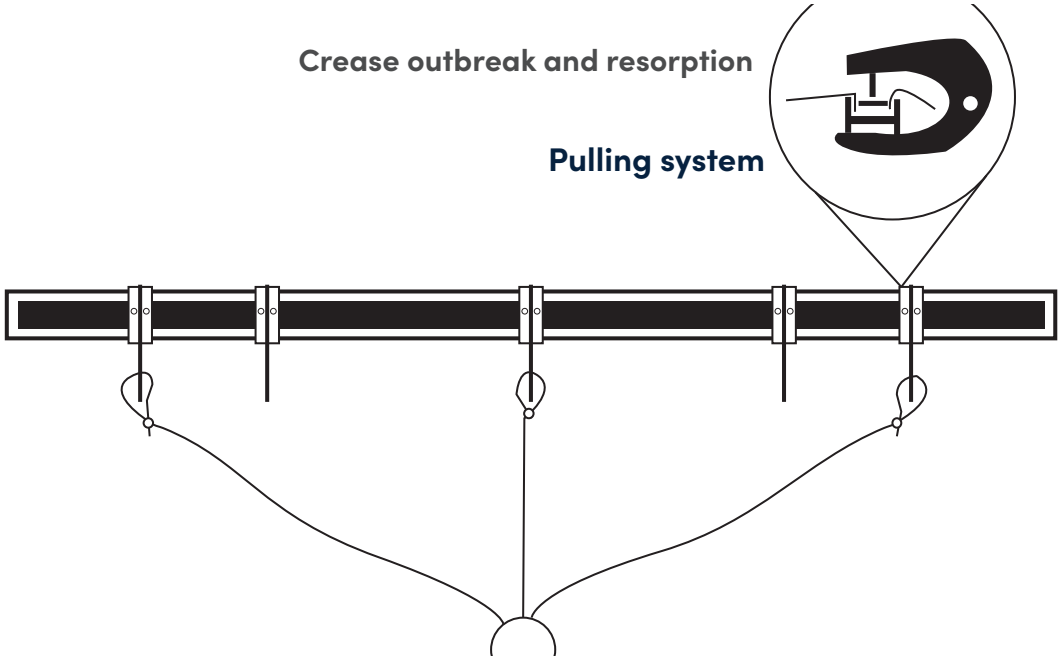
HOT MIX ASPHALT OR MACADAM

Bituminous geomembrane has one a major difference from other synthetic geomembranes: it is compatible with hot mix asphalt or macadam, thus allowing a perfect waterproofing continuity between a road surface and the side ditches, by catching the edge of the geomembrane between the asphalt layers.

With a thickness of 5 to 8 cm (2 to 3 in), a maximum grading of 10 mm (0.4 in), and a rich mix-design (bitumen content increased by 0.5 to 1.0 % compared to standard recipes), hot mix asphalt can be placed directly on the geomembrane, without laying an intermediate geotextile.

Cores on samples show that the aggregates of the asphalt mix slightly entered the upper surface of the geomembrane, and a mixing of the binders for a thickness of a few millimeters.

▲ Details of contact between a light colored hot mix asphalt and bituminous geomembrane

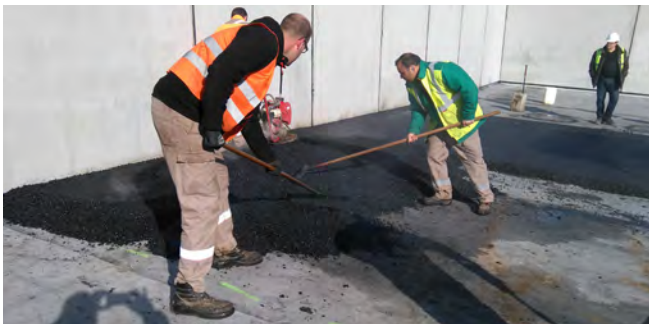


When laying hot mix asphalt, temporary creasing may appear through the following mechanism:

- Under the friction effect between the materials pushed by the paver's screed, a crease may appear between the paver's tracts and the screed;
- The screed then covers this crease with hot mix asphalt;
- The heat of the hot mix asphalt then allows the crease to release;
- The lack of asphalt mix that appears is then compensated by hand.

This temporary creasing phase does not have any consequence on the geomembrane behavior. Cold asphalt may also be used as a protective layer.

To reduce the creases described previously, which the heat of the materials cannot absorb, it is advised to lay them with a grader instead of a paver.



CONCRETE - COBBLESTONES

A protective layer, either rigid (in-situ cast concrete slabs), or granular (cobblestones) can be placed on the Coletanche geomembrane.

A 250 to 500 g/m² (7.4 to 14.8 oz/yd²) polypropylene geotextile is generally placed in between the geomembrane and the concrete (polyester may be hydrolyzed by the free lime of the concrete), to drain pressure from underneath, which might appear if the water level is quickly lowered in the pond.

Cobblestones can be contained either by a boot abutment or anchored with stainless steel cables from the crest.

▲ Pre-cast cobblestones, anchored from the crest

GRAVEL

As for cold mix asphalt, it is not necessary to lay a geotextile between the Coletanche and the protective gravel layer. Depending on the aggressiveness of the material (grading, angularity), a thinner or thicker type of Coletanche will be used.

▲ Laying rolled gravel on Coletanche

▲ Puncture by aggregates results: no holes

BALLAST

Gravel and ballast are laid with a minimal thickness of 20 cm (8 inch).




▲ Laying ballast on Coletanche

If those materials are placed by pushing forward with a loader or a small bulldozer, then the friction may generate a slight elongation of the geomembrane.

To avoid creases that may then collapse, it is advised to leave one end of the geomembrane free, and weld it only at the end of the work phase.

ROCKS OR GABIONS

As previously indicated, the purpose of the geomembrane is to guarantee watertightness, but it does not increase the structural capacity.

Therefore, the bearing capacity of the subgrade is a key factor when laying rocks or gabions to prevent the geomembrane from tearing under the weight of the protection.

A thick geotextile of 800 to 1,000g/m2 (23.59 to 29.49 oz/yd2) is often advised between the membrane and the protective layer.

▲ Laying rocks

▲ Angliers Dam (Témiscaminque, Quebec)

▲ Landfill capping

▲ Diavik (Northwest Territories, Canada)

▲ Motorway 4.5m in aquifer (Kildare, Ireland)

TOP SOIL – GRASSING - PLANTING

For aesthetic reasons, topsoil covered with grass or planting is another solution to protect Coletanche, in ditches, as landfill cover or on pond slopes.

If the slopes are too steep (higher than 1/1) for the internal friction angle of the topsoil, it can be maintained through the use of geogrids.

▲ Topsoil and grassing

▲ Example of reverse installation Radioactive waste. (Andra, La Hague-France)

Grass, weed or small tree roots do not punch the geomembrane, due to the anti-root film.
For larger trees, species with flat roots are required.

6.2. MAINTENANCE

Before the beginning of the construction, it is important to bring to the client's attention their future needs for maintenance of the structure.

Maintaining a structure may be a part of its operating cycle: This is the case for ponds which receive waters with material in suspension and which need to be periodically emptied. This may lead to the construction of ramps, and to the choice of a different protective layer, in order to lighten the task of the operation in the future.

Maintenance also deals with the geomembrane itself, and periodic inspections (every one, two or three years) allow the correction of small defects that may appear, before they reach a critical stage (opening of seams, punctures).

Because Coletanche is very easy to repair, using the same techniques as those applied during installation, these operations are fast and simple to do.

The operator himself can do such tasks, though a commercial proposal by the installer can be suggested, to perform a periodic inspection and preventive maintenance.

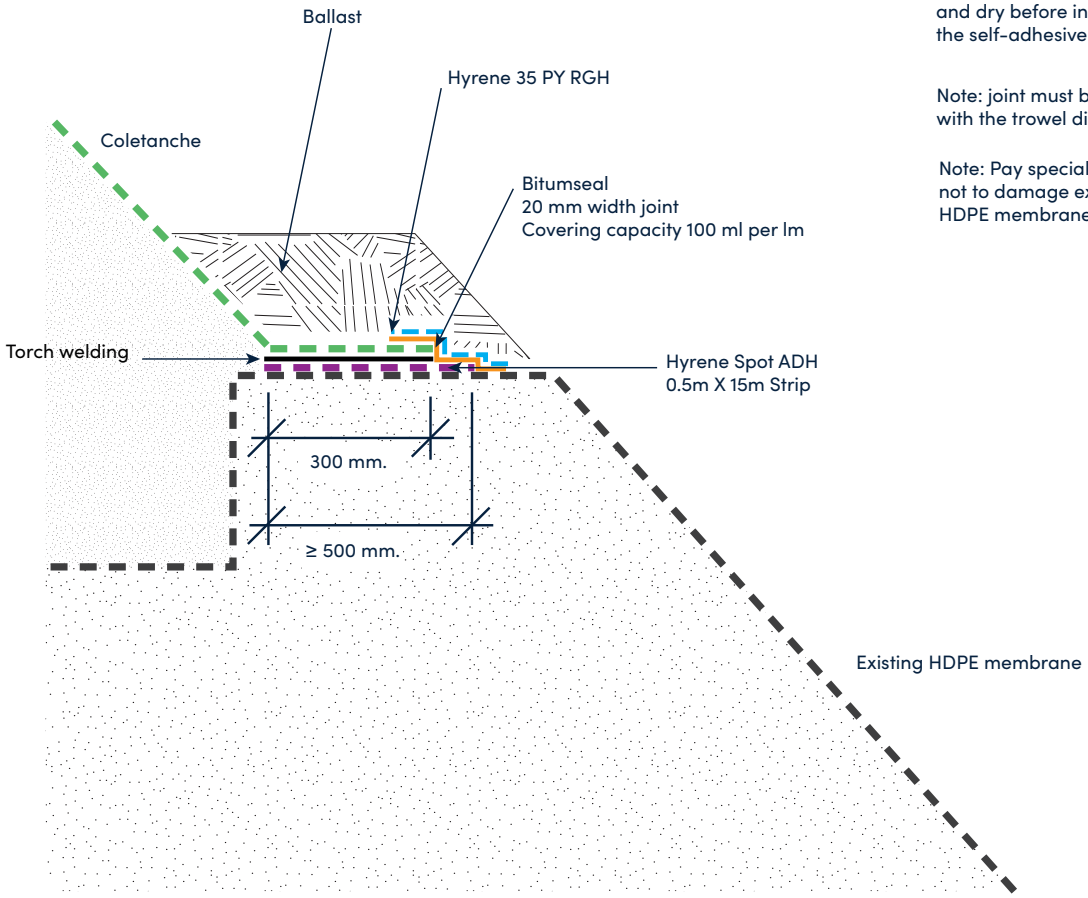
6.3. EXTENDING THE PROTECTION OF A PREVIOUSLY INSTALLED HDPE MEMBRANE USING COLETANCHE

Coletanche geomembranes can sometimes be used in projects where another type of geomembrane was installed during a previous phase. For example, Coletanche can be adhered to a previously installed HDPE geomembrane. The junction between the two has to be bonded using an adhesive, since these two geomembranes cannot be welded together by heat.

The adhesive used is **Hyrene Spot ADH,** which is a stabilised polyester reinforced SBS elastomeric modified bituminous waterproofing membrane. The under surface is covered with a peel-off film which exposes a heat activated base layer to later use a torch to weld both membranes together. It exists in two widths : 1m and 0.5m.

Bitumseal is a durable plasto-elastic, adhesive and sealant based on bitumen, selected elastomeics and resins that adheres on most building materials, even on wet surfaces. Bitumseal forms a smooth skin and remains flexible. Surfaces must be clean and free of defects, before the product can be applied using a trowel or a spreader equipped with a heated nozzle. It forms a strong bond with a wide variety of materials without the need for a primer.

Extending the protection of a previously installed HDPE membrane using Coletanche



Note: Surfaces must be clean and dry before installation of the self-adhesive membrane

Note: joint must be smoothed over with the trowel directly after installation

Note: Pay special attention not to damage existing HDPE membrane

For more details on this technique, please contact your Coletanche representative.

7. DOCUMENTATION & APPENDICES

ADDITIONAL ITEMS ON THE COLETANCHE WEBSITE:

- TECHNICAL DATA SHEETS
- SAFETY DATA SHEETS
- CERTIFICATES
  - CE MARKING CERTIFICATE
  - ISO 9001 & 14001
  - SNCF (FRENCH NORM) NTP4 ES4
  - ASQUAL CERTIFICATIONS (FRENCH NORMS)
- DECLARATIONS OF PERFORMANCE (CE MARKING)
- SPECIFICATIONS
  - COLETANCHE INSTALLATION SPECIFICATIONS
  - SPECIFICATIONS FOR UNDERGROUND STRUCTURES

UPON REQUEST TO YOUR LOCAL CONTACT:

- COLETANCHE TENDER SPECIFICATIONS TEMPLATE
- SITE PREPARATION CHECKLIST
- SITE SUPERVISION
- SAMPLE LIST OF TOOLS
- ACCEPTANCE FORMS
  - Suport Layer Acceptance Form
  - Roll Acceptance Form
  - Laying Summary Form
  - Seams Testing Form

Non exhaustive list, contact for more detailed information: **info@coletanche.com**

COLETANCHE ON THE INTERNATIONAL SCENE

IKO-AXTER
6 rue Laferrière
75009 Paris
France
Tel. + 33 32 793 1020
info@coletanche.com
info@axter.eu

AXTER
Rue Joseph Coste
59552 Courchelettes
France
Tel. + 33 32 793 1020
info@coletanche.com
info@axter.eu

AXTER ILLZACH
33 rue des 3 Frontières
68110 Illzach
France
Tel. + 33 38 961 5161
info@axter.de

AXTER IBÉRICA
#180 P.I. Ca N'Illa
Avda. Jacint Verdaguer,
26 08530 La Garriga (Barcelona)
España
Tel. + 34 93 871 7333
info@axter.es

IKO COLETANCHE SUDAMERICA
La Concepción, 65, #904
Providencia
7500010 Santiago de Chile,
Chile
Tel. + (56-22) 236 99 39
info@axter.es

AXTER CZ. REPUBLIC
Eliášova 20 -
160 00 Praha 6
Czech Republic
Tel. + 420 222 951 195
info@axter.info

AXTER LIMITED
Harbour Landing, Fox's Marina,
The Strand, Wherstead,
Ipswich IP2 8NJ,
Royaume-Uni
Tel. + 44 1 4737 240 56
info@axterltd.co.uk

AXTER COLETANCHE INC.
3550 Côte-des-Neiges #650
Montréal, QC H3H 1V4
Canada
Tel. + 1 (514) 903-1912
info@axtercoletanche.com

AXTER AUSTRALIA
#1302, 50 Cavill Avenue
4217 Gold Coast
Australia
Tel. +61 (7) 56 35 44 89
info@axter.com.au

IKO COLETANCHE USA
531 Roselane ST, NW Suite 400
Marietta, GA 30060
USA
Tel. +1 (470) 599-6766
info@coletanche.com

COLETANCHE®