



ARMOURFLOW™

VERTICAL DRAINAGE & PROTECTION INSTALLATION GUIDELINES

FOR WALLS BURIED IN THE GROUND



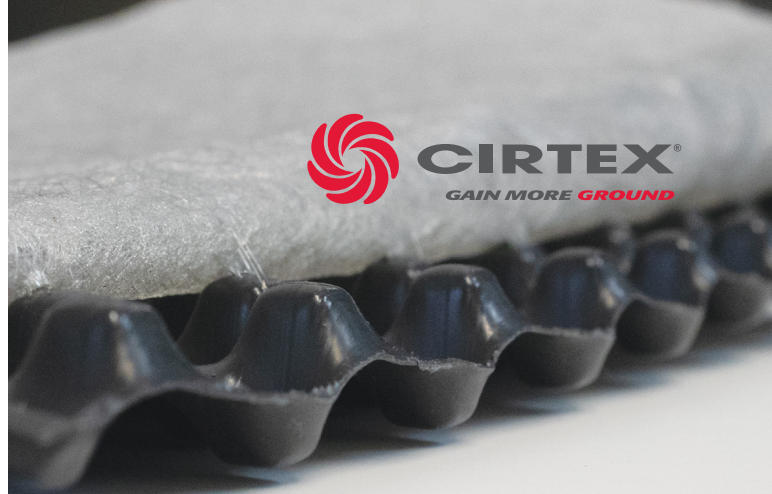
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VERSION 2

INSTALLATION GUIDELINES VERTICAL DRAINAGE PANEL





1. GENERAL DEFINITION

1.1. PURPOSE

In the case of buried walls, especially in civil engineering applications (retaining walls, abutments, foundations) infiltration water or groundwater may destabilise the structure by the hydrostatic pressure exerted.

Most often, these walls are sealed to protect the concrete from the corrosive action of water.

These sealing layers must be mechanically protected, especially during the backfilling operations.

The object of Armourflow is to carry the seepage water coming from the soil to a draining collector and to mechanically protect the sealing layers.

1.2. ARMOURFLOW

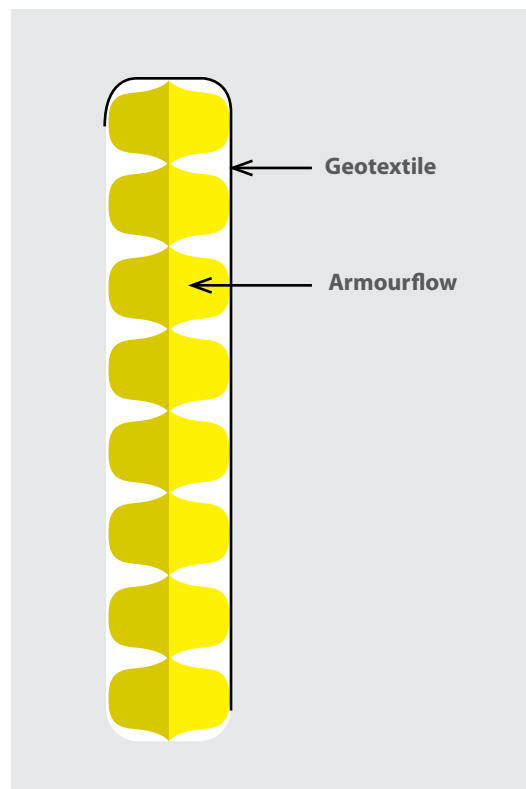
Armourflow is a drainage geocomposite made of a symmetrical and impermeable thermoformed HDPE honeycomb geospacer, covered on one side by a geotextile.

1.3. FUNCTIONS

Armourflow fulfills three essential functions for the longevity of the works:

- Stop and remove infiltration of water from the water table, and thus reduces the hydrostatic pressure acting on the buried walls.
- Maintain a gap of air along these walls
- Protect the waterproofing layers from the risk of mechanical damage, especially during embankment construction.

Its real performance lies both in its ability to maintain a high flow under stress and its ability to mechanically protect the sealing layers.



ARMOURFLOW: CROSS SECTION



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2. PHYSICAL CHARACTERISTICS

Armourflow is made of two elements:

- High-density polyethylene honeycomb structure, called a geospacer
- Nonwoven geotextile

2.1. GEOSPACER OR CORE

- Manufacturing process: extrusion of a polyethylene sheet, then thermoforming
- Production site: France
- Appearance: Double Cuspated Sheet, symmetrical
- Colour: Black
- Thickness: 10 mm ($\pm 10\%$)

2.2. GEOTEXTILE (FILTER)

The geotextile used to ensure the filter function is a geotextile compliant with CE marking requirements. Its identification characteristics are as follows:

- Manufacturing process: nonwoven of thermolated continuous filaments
- Mass per unit area (NF EN ISO 9864): 125 g / m² ($\pm 10\%$)

2.3. CHEMICAL COMPOSITION

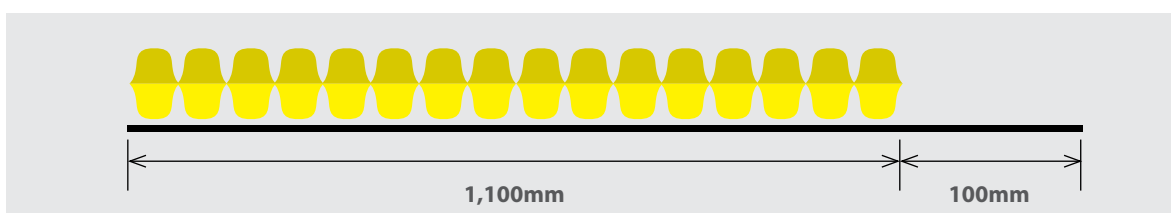
Nature of constituents:

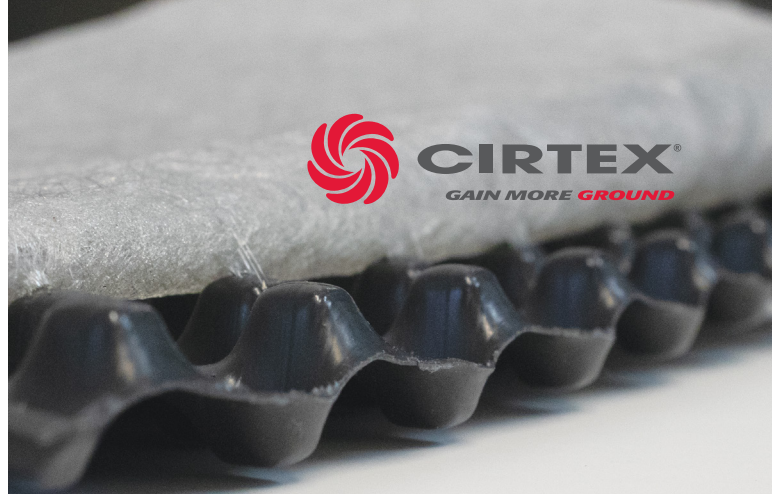
- Geospacer: high density polyethylene
- Geotextile: polypropylene

These two constituents give Armourflow a chemical inertness with respect to salts, bases, acids and petroleum products present in the ground.

2.4. FINAL PRODUCT : ARMOURFLOW

Armourflow is made of a geospacer covered on one side by a filter geotextile wide by 100mm than the geospacer. The geotextile flap is folded down and held by a tacky glue to open and re-glue the geotextile, making it easier to cover the connections.





The method of assembly is achieved by hot gluing.

- Width of geospacer: 1.1 m (other widths possible)
- Width of the geotextile: 1.2 m
- Usual length: 25 linear meters
- Weight of a roll: about 26 kg

During the coating process, the geotextile is on the inside of the roll, to facilitate the implementation.

2.5. IDENTIFICATION - MARKING

Armourflow is a drainage geocomposite: it is therefore subject to CE marking, and more specifically to standard NF EN 13252 (characteristics required for use in drainage systems).

A label with the name and type of product is fixed to all rolls. All rolls are marked, by indelible ink jet, every 5 m (in accordance with standard NF EN ISO 10320: "Identification on site").

**PRODUCT MARKING:
ARMOURFLOW**

The DoP (declaration of performance) supplied on request by the producer, mention all the information required by standard NF EN 13252.

2.6. MANUFACTURING AND SELF-CHECKING

Armourflow is manufactured in France.

Traceability: from the traceability label, it is possible to identify both the geotextile and core roll produced at the site with all the production parameters. Thus, a label attached to one of the two strings mentions:

- Item code
- Lot number
- N° of the roll
- Length
- Production site

CE Certificate of Factory Production Control No. 0334-CPR-0003

The quality system of the manufacturer is certified according to ISO9001 version 2015



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3. PERFORMANCE CHARACTERISTICS

3.1. COMPRESSIVE RESISTANCE

Short-term compressive resistance

The compressive strengths are carried out according to the EN ISO 25619-2 standard for each production.

Short-term compressive strength > 250 kPa

Long-term compressive resistance

Like all plastic products, especially those made from polymer, Armourflow is subject to creep over time. The thickness of the product decreases with time under constant stress. Thus, the compressive strength and shear stress test report under 100 kPa (Cemagref test report n° 04.034 / 01), carried out according to EN ISO 25619-1, shows that, under this constraint, the product thickness is greater than or equal to 89% of the thickness under 100 kPa, after 100 years. The air gap between Armourflow and the buried wall is thus preserved, even in the long term.

Compressive strength and long-term shear > 100 kPa

3.2. LONG-TERM RESISTANCE - DURABILITY

The durability tests use the notion of residual strength, ie the ratio between the maximum tensile strength of a specimen after accelerated aging (according to various test standards) and the maximum tensile strength of a control sample to quantify the deteriorations.

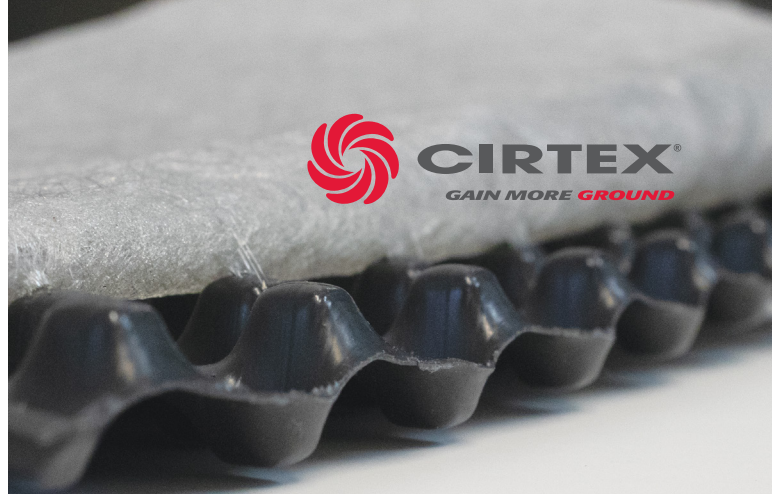
Resistance to climatic agents

The tests carried out after aging according to standard NF EN 12224 * "determination of the resistance to climatic agents" do not show a significant modification of the tensile strengths.

Armourflow should not be exposed to the sun more than two weeks

* Accelerated aging consists of 100 hours exposure to xenon arc lamps, with cycles consisting of 18 minutes of watering followed by 102 minutes of UV.





Resistance to chemical agents

The tests carried out after aging according to the standard ENV ISO 12960 * "test method for the determination of the resistance to liquids" do not show any significant modification of the tensile strengths.

Armourflow can be used in all natural soils, without pH restriction.

*Accelerated aging consists of immersion for 3 days at 60 ° C in an acidic solution (method A) or in a basic solution (method B).

Microbiological resistance

The tests carried out after aging according to the standard NF EN 12225 * "method for the determination of the microbiological resistance by a burial test" do not show any significant modification of the tensile strengths.

Armourflow is not altered by the microbiological activity.

*Accelerated aging consists of burial in a soil with stimulated microbial activity for 26 days.

Lifetime

The tests carried out after aging according to ISO TR 13438, method A *, "method of determining the resistance to oxidation" by the IFTH (report no. 10758 part 1 - 10/09/02) do not show significant modification of tensile strengths.

Oxidation tests, following the same principle, at different temperatures, for longer periods of time, made it possible to draw an extrapolation line (according to the Arrhenius law - technical file durability - November 2003).

The lifetime of Armourflow is presumed greater than 100 years, for use temperature below 25°C

*Accelerated aging consists of exposure at 110 ° C for 28 days.

The compatibility of the backfill soil to the geotextile filter must be checked by the design engineer to ensure adequate performance for the life of the project.



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3.3. PUNCHING RESISTANCE – PROTECTION

Hydraulically:

Armourflow drains the water percolating through the soil up to a drain:

1. Its waterproof geospacer prevents waterflow to the wall. The joins may not be watertight.
2. Its symmetrical geospacer ensures the conservation of an air gap against the wall.

Mechanically:

- Armourflow, positioned between the floors and the structure, protects the waterproofing, especially during the implementation of embankments, by its mechanical characteristics (dynamic perforation and pyramidal punching on rigid support)
- Its geospacer of continuous structure constitutes an “obstacle”, thus a protection, in every point of the waterproofness (static punching or CBR)
- Mechanical characteristics of Armourflow:
 - Dynamic perforation (NF EN 918): 5.9 mm (+ 40%) - CER test report No. 0505210306U
 - Pyramidal punching on a rigid support (NF EN 14574): 499 N (-30%) - CER test report n ° 0505210306X

**Dynamic perforation of
a protective geotextile,
type P80 (800 g/m²):
8mm**

3.4. HYDRAULIC CHARACTERISTICS

Filtration opening * (NF EN ISO 12956): 130 µm (± 30%)

Permeability to water * (NF EN ISO 11058): 0,055 m / s (- 30%)

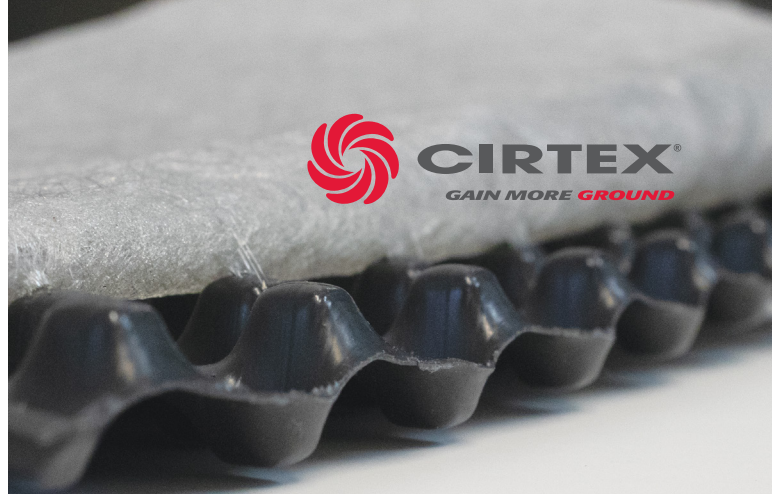
Flow capacity ** (NF EN ISO 12958):

- $i = 1$; under 50 kPa: $q_{50} / 1 = 3.1 \cdot 10^{-3} \text{ m}^2 / \text{s}$ (-15%)
- $i = 1$; under 100 kPa: $q_{100} / 1 = 2.7 \times 10^{-3} \text{ m}^2 / \text{s}$ (-15%)
- $i = 1$; under 200 kPa: $q_{200} / 1 = 2.2 \cdot 10^{-3} \text{ m}^2 / \text{s}$ (-15%)

* characteristics measured on the filter

**configuration of the test = rigid plate / foam plate





4. FIELD OF EMPLOYMENT

The Armourflow range is intended for vertical drainage of buried walls in the field of civil engineering, for any type of structure:

- Bridge foundations, retaining walls, trenches, underpass under right-of-ways, tunnels.
- Armourflow can be used directly against a buried wall (with or without water proofing) before backfilling.
- In the case of an excavation, Armourflow can also be used against the ground (geotextile against the ground), with the possibility of projecting or pouring concrete on its other side (which reduces the flow capacity of the product).

Armourflow must be associated with a drainage collector at its base. In most cases, a diameter of 80 mm is sufficient. The drain must be dimensioned from a hydraulic and mechanical point of view. For this, it is necessary to define the quantities of water to be evacuated and to respect the limits of use defined below.

The dimensioning of the collector drain, as well as the dimensioning of the filter opening of the geotextile, are not the subject of this document.

The use of a suitable collector drain is recommended: double-walled drain type, compliant with standard NF P 16-351, classification SD (rolling loads). The non-functionality of the collector drain calls into question all the drainage of the structure. Specific couplings to weep hole also allow the durability of the drainage system avoiding any dislocation.

4.1. HYDRAULIC DESIGN RULES

The maximum amount of water to be evacuated must be given by a competent design office. If this data is not measured, it can be estimated according to the permeability of the ground.

For example, 1 m² of Armourflow 10 (1 m² of contact with the backfill) used in a ground of permeability 10⁻⁶ m² / s will have to remove a maximum flow rate of 3.6 l / h.

Armourflow can also be dimensioned according to the capacity of the draining collector; In this case, it must not be a limiting factor.

	Classification ND	Classification SD
Crushing test Ring stiffness (kN/m ²)	>4	>8
Choc test Minimal height (m) H 50 (m)	0.8 > 1.2	1.0 > 1.2

Required characteristics of the drains according to the standard NF P 16-351



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4.2. MECHANICAL DESIGN RULES OF DRAINAGE GEOCOMPOSITE

The long-term compressive strength, equal to 100 kPa (see section 3.1) must always be greater than the horizontal stress, called earth pressure, exerted by the earth backfilled on the product.

The calculation of this pressure of earth is done either with the coefficient of the earth at rest, or with the coefficient of thrust (active).

The choice of the coefficient depends on the application: if the buried wall admits a displacement (case of the retaining walls), it is necessary to consider K_a ; otherwise (no displacement possible), K_0 must be considered.

Earth pressure is therefore defined by the relation:

$$P = K \cdot \gamma \cdot z \text{ with : } \begin{aligned} K &= K_0 \text{ ou } K_a \\ K_0 &= 1 - \sin \phi : \text{Coefficient of resting earth pressure} \\ K_a &= \tan^2 \left[45 - \frac{\phi}{2} \right] : \text{Coefficient of thrust} \\ \phi &: \text{Internal friction angle in } ^\circ \\ \gamma &: \text{Volume density of earth, in kN / m}^3 \\ z &: \text{depth in m} \end{aligned}$$

This constraint is therefore all the higher as:

- The height of the buried wall is important,
- The backfilled ground is loose (too little compaction energy, too large passes, unsatisfactory soil water content, etc.).

Armourflow can therefore be used up to a maximum installation depth of between 7.5 and 15.0 m, depending on the application (calculations performed with a density of 20 kN / m³).

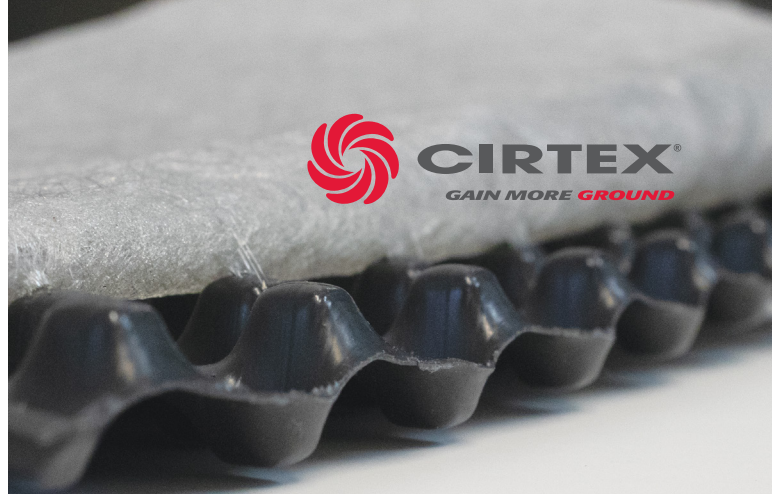
4.3. SUPPORTING REQUIREMENTS

The supports must be stable and flat, have a clean surface, free of any foreign body and without stains (oil, plaster, hydrocarbons, etc.)

In a more general way, the walls will have to present a state of surface according to the rules of the art:

- Masonry walls used in the basement: Clause 3.7 of the CCT of standard NF P 10-202 (DTU 20.1)
- Surface condition of the masonry wall: paragraph 5.2 of the CCT of standard NF P 10-202 (DTU 20.1)
- Supported concrete supports: DTU 23.1
- Concrete concrete facings: paragraph 5.2.1 of standard NF P 12-201 (DTU 21).



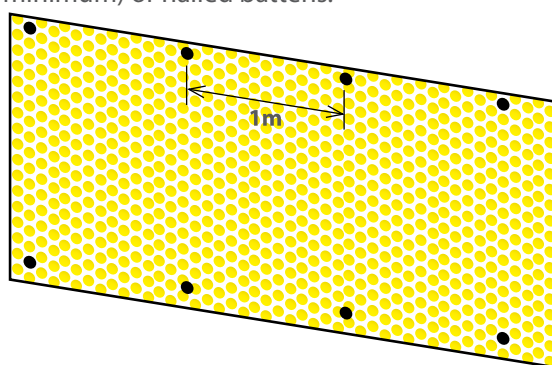
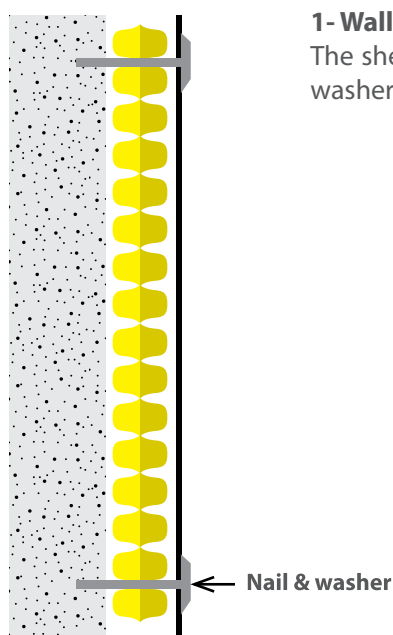


5. IMPLEMENTATION

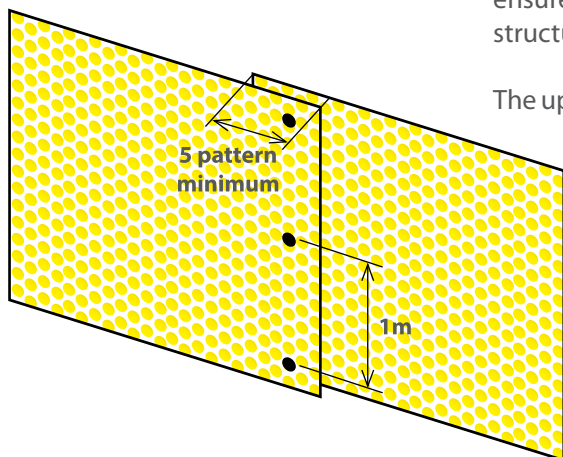
5.1 GENERAL SCHEMES

1- Wall Fixing

The sheet should be attached to the wall using either steel nails with a washer (25 minimum) or nailed battens.



The strips can be laid in both directions: vertically and horizontally. They must be fixed at the top and bottom, all linear meters. These fasteners maintain the product in place, to prevent soil from entering between wall and sheet during backfilling. **When the overlap is horizontal**, it is advisable to first install the sheet in the lower part, then to adjust the sheet in the upper part so that it does not exceed the finished level of land. There is no need to cut the top roll in its height to limit overlap between the rollers. This covering must be effective on 5 patterns, or 10 cm. First take off the edge of the filter, then superimpose the structures by interlocking, and finally fold down the filter to ensure continuity in the height. Ensure the tile effect of the structures



The upper roller is then fixed in the same way as the previous one : in the upper part and in the lower part, all the linear meters

2 - Side connections

Just take off the edge of the filter, superimpose the structures by fitting them on 5 patterns, a width of 10 cm. The meaning of the superposition is indifferent. Mechanical fasteners (identical to those indicated in section 1) must be implemented at the right of the connections, all linear meters.



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3 – Drainage at the base

The evacuation of water at the base of the wall must be provided by a perimeter drain collector. It must be completely covered with the filter. It must be connected carefully to the evacuation network.

This collector must meet the NF P 36-151 standard (SD category) and its design must comply with the requirements of the appendix to the booklet "Design rules and minimum construction provisions" of standard NF P 10-202 (DTU 20.1).

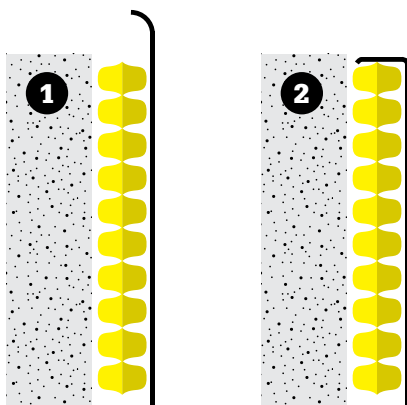
4 – Backfilling and compaction

The backfill must not be saturated and must not contain pieces of sharp edged stones greater than 10 cm in diameter. Be sure to maintain a sufficient distance between the compactor and Armourflow. At close distance from the wall, compacting should be done with light equipment.

5.3. SHIPPING / STORAGE

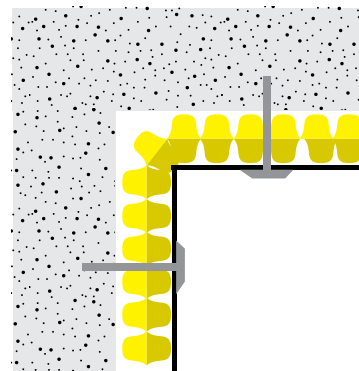
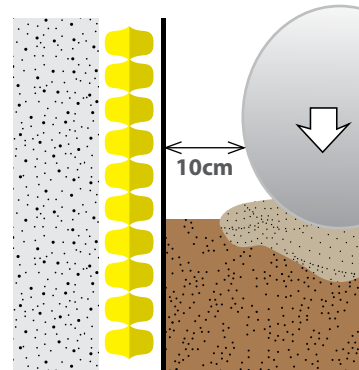
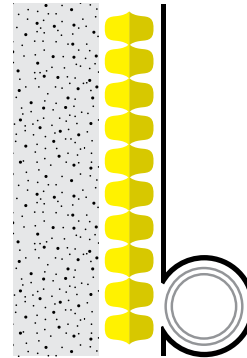
The product is delivered in rolls on timber pallets

5.2. SINGULAR POINTS



1 – Closure at the top

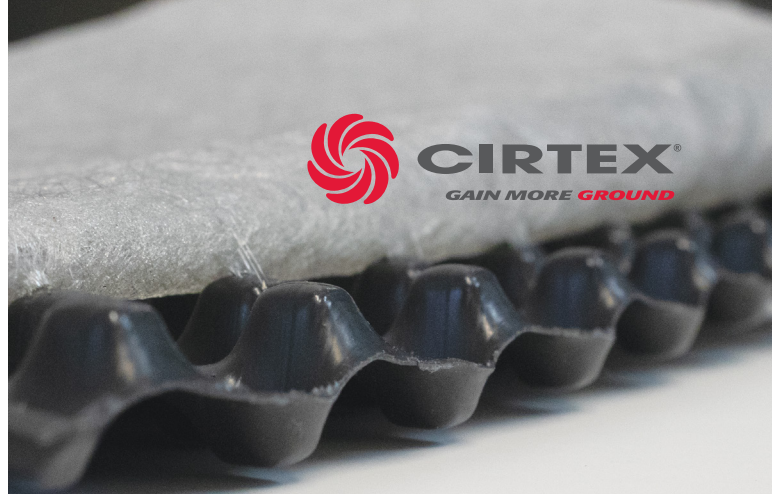
The filter must be folded behind the honeycomb structure to prevent the entry of embankment soil.



2 – Angle treatment

Armourflow is placed in the corners (inside or outside) by folding them. Fixings must be provided on both sides of the corner.





filmed.

Pallet storage is not mandatory, but it must be done in a clean place. The rolls can be stored flat, or preferably vertically, and are in both cases stackable on two heights.

Armourflow should not be in direct UV exposure for more than 2 weeks.

6. MAINTENANCE

Armourflow does not require any special maintenance.

Repair in case of damage during installation:

- If the filter geotextile is torn, it is enough to lay on the whole damaged surface, and beyond, a piece of the same geotextile. It can simply be glued while waiting for backfilling;
- If the structure is moved or broken, repair or replace it to ensure continuity of the drainage system.

7. COMMITMENT OF MANUFACTURER

7.1. USER ASSISTANCE

On request, the manufacturer can determine the product of the Armourflow range corresponding to the specific constraints of the construction site (mechanical and hydraulic), with, if necessary, technical assistance from the construction site to carry out the implementation.

8. SUMMARY OF REFERENCED DOCUMENTS

- Compressive strengths (internal tests)
- Water flow capacity (internal tests)
- Creep in compression and shear (Cemagref test report n ° 04.034 / 01)
- Dynamic perforation (CER test report No. 0505210306U)
- Pyramidal punching on a rigid support (CER test report No. 0505210306X)
- Report n ° 10758 part 1 (10/09/02)
- Report n ° 10758 part 2 (01/10/02)
- Technical file sustainability (18/11/03)



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CIRTEX INDUSTRIES LTD

Head Office

16 Queen Street, Kopu, Thames 3578, New Zealand

0800 CIRTEX (247 839) | WWW.CIRTEX.COM.AU

