

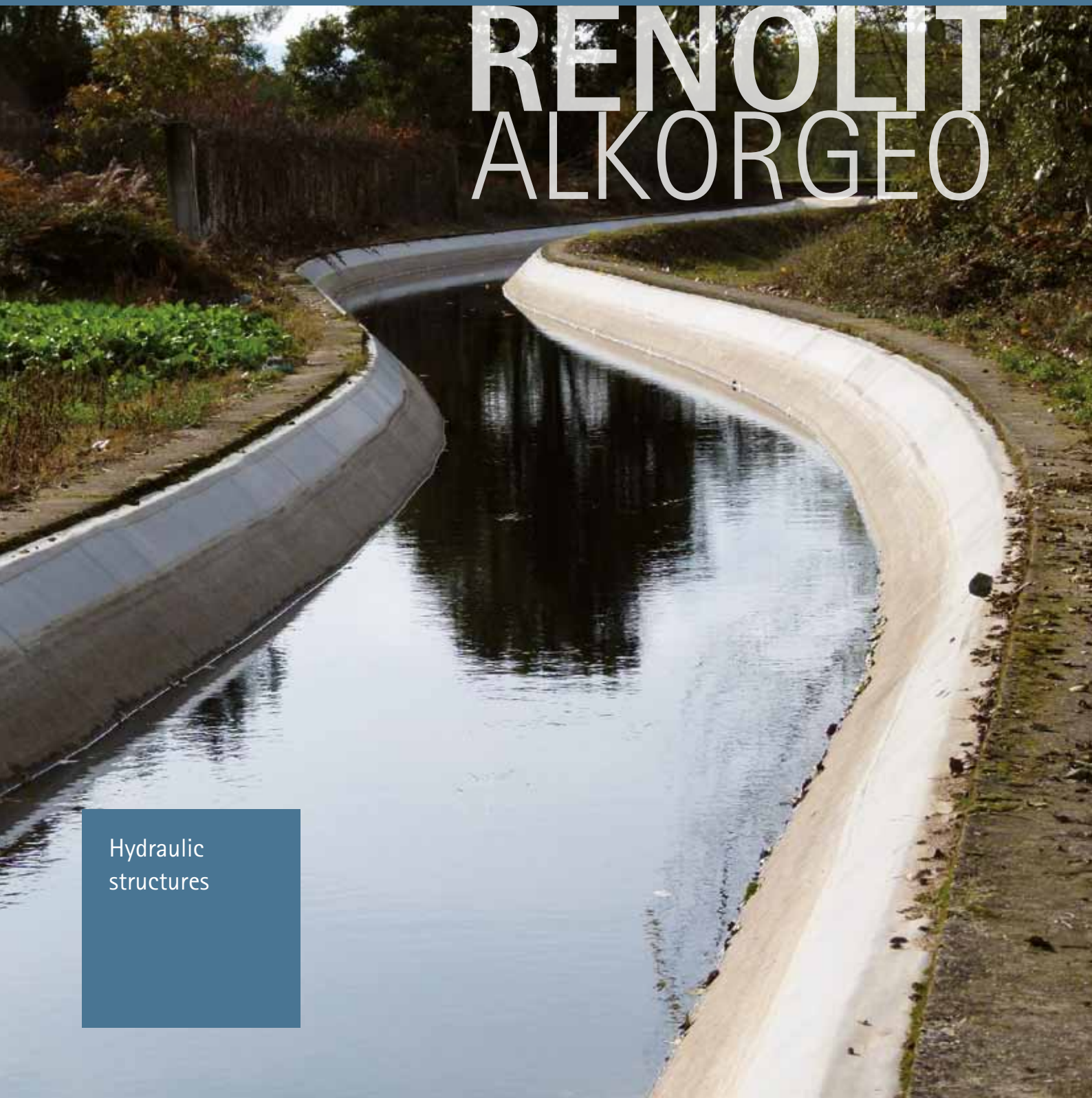


Rely on it.

Waterproofing of Canals

RENOLIT ALKORGEO

Hydraulic
structures



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Hydraulic structures



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Geomembrane recommended

RENOLIT Group manufactures and markets a complete range of PVC, PE or PP geomembranes in response to a wide variety of applications. Experience has shown that the PVC geomembrane is the most suitable for waterproofing of hydraulic structures due to its excellent mechanical properties, weld ability, resistance to UV and durability.

Specifically for the waterproofing of canals, RENOLIT ALKORPLAN developed a PVC geomembrane for hydraulic works with a reinforced resistance to microorganisms and UV, thanks to the addition of a top layer of PMMA : RENOLIT ALKORPLAN 35554.

If necessary, the geomembrane is also available with a special formulation for storage of potable water: RENOLIT ALKORPLAN 35052.

In addition, this geomembrane can be laminated with a geotextile in polyester or polypropylene (up to 700 g/m²) and receive a reinforcement grid made of polyester or glass.

Installation of canal lining

Concept of the Waterproofing System

It is necessary to study the exact conditions under which the waterproofing system has to be installed and has to work. Different parameters can lead to a malfunction of the system. Therefore the geological and geo-technical conditions have to be investigated on site.

In general the waterproofing system consists of:

- Support
 - Drainage layer
 - Protection layer
 - Filter layer
- Waterproofing layer
- Protection
 - Synthetic protection
 - Mineral protection
 - Combination

Drainage

The drainage has to ensure the evacuation of liquids and gas under the geomembrane.

For new projected canals a study before their execution should be carried out concerning the drainage, as wrong execution can lead to important failures of the waterproofing system.

Drainage for water/gas should be foreseen under the following circumstances:

- when the soil under the waterproofing system contains organic matter
- when the soil is karstic or susceptible to internal erosion
- when the canal is subjected to rapid tidal rises
- when temporary groundwater can develop under the geomembrane

Drainage for water

Drainage for water can be done as follows:

- Layer of granulates in a thickness of 10 cm with minimum of 60 % sand, $0,5 < D < 5$ mm. A synthetic separation layer (filter) has to be placed between the ground and the drainage layer.
- A net of drainage ditches has to be installed in order to collect the upcoming liquids. The drainage pipes are covered with a transmissive geotextile to avoid collimating of the pipes due to fine granulates.
- Geosynthetic drainage in combination with drainage pipes.

Preparation of the Support

Quality of soil

The quality of soil is of importance. Research needs to be done to check for the existence of gas and organic material in the soil. As this could mean that a drainage system has to be fitted underneath the waterproofing system to evacuate developing gas.



4 Waterproofing of canals

Collectors and outlets

All liquids are guided into collectors, leading to outlets where they are evacuated through gravity. If an evacuation with gravity is not possible it has to be done via pumping. In this case a well has to be constructed at the lowest point, containing an automatic pump. This well has to be controlled frequently. It also serves as control for the functioning of the water proofing system.

Dimensioning of drainage

To dimension the drainage the following has to be taken into account:

- quantity of upcoming liquids behind the geomembrane
- quantity of liquid in case of a failure of geomembrane
- the maximal negative pressure in case of a quick emptying of the basin or a failure of the waterproofing system.

In small projects half perforated pipes with a diameter of 125 mm in combination with bands of geo spacer in 0,2 m to 0,5 m width are generally used. For big projects the drainage system has to be dimensioned following the actual situation.

Sub Grade

The surface has to be smooth, without sharp stones, vegetation and well compacted to avoid relative settlements. In case of renovation of old concrete canals the concrete has to be repaired.



Installation of waterproofing system

The waterproofing system

After determining exactly the parameters of the soil and the sub grade the waterproofing system can be decided.

In general the waterproofing system consists of:

→ Separation or/and protection layer:

Geotextile of min 500 g/m² will be placed on the prepared sub grade (drainage layers). Its task is to protect and to separate the geomembrane from the sub grade. In case the last layer under the geomembrane consists of sand, precautions have to be taken during the welding of the geomembrane to avoid polluting of the welding zone (Strips of geomembrane placed under the actual welding zone and pulled in the direction of the welding process following the progress of welding).

→ Geomembrane:

The choice of the geomembrane should be done following the task the geomembrane has to fulfil (PVC, PP or PE).

Installation of geotextile

The geotextile can be produced in different widths. Depending on the construction the width is very important. For large surfaces the maximum width (up to 8 m) should be used. It may be useful to combine 2 different widths in order to cover the whole project. It is difficult to cut the geotextile therefore some smaller roles can lighten the works.

Installation of the Geomembrane

Prefabrication of panels

For large surfaces it is recommended to prepare large panels. This especially concerns PVC geomembranes which are produced in widths of 2,05 m. In the prefabrication phase panels of any size can be produced.

The advantages of prefabrication are as follows:

- Quality of welding is very high as the conditions in prefabrication do not change.
- Reduction of cost compared with welding on site.
- Reduction of working time as prefabrication can start before installation on site.
- Reduction of welding on site, therefore failure of welding on site is reduced.

→ Reduction of testing time.

To be able to produce in prefabrication it is necessary that:

- engines on site are available to place the panels without destruction;
- deploy an exact assembly plan following the condition of the site.

The welding has to be carried out with an automatic welding machine. It is recommended to use a machine with double welding in order to be able to control the welding with air pressure. In case of a simple welding seam it is recommended to control this with an iron pipe (opening about 3,0 mm) with air pressure.

The panels are folded in case of minor thickness of geomembrane or rolled on a large mandrill for more important thickness. To avoid destruction of the panels they have to be carefully packed for safe transportation to the site.

Assembling of panels

The assembling is executed following the plan of installation. The prefabricated panels are numbered to help with the installation and also for identification purposes.

In general the size of panels is between 200 m² to 1.000 m² depending on:

- Thickness of the geomembrane
- Means of manipulation in the prefabrication as well as on site
- Accessibility and configuration of site
- Way of folding of panels
- Size of canal

For PP and PE in most cases it is not necessary to prefabricate the panels as the production width can be superior to 5 m.



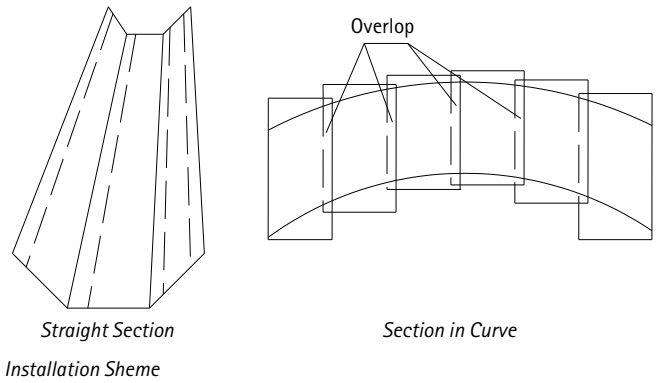
Placing of geotextile

Installation on site

a) Geometry and size of Canal

The geometry and the size of the canal are important to determine the installation method.

Long and straight sections should be installed longitudinally, curves in a transversal way. Therefore it is recommended to establish an installation plan.



b) Placing the Geomembrane

→ The installation of the geomembrane of the prefabricated panels can only be executed if all works concerning the sub grade (layers of granulates, separation layer, drainage) are completely finished and approved by the responsible site engineer.

→ The geomembranes are unrolled without tension and overlap. The overlapping depends on the used welding machine (4cm to 10 cm). Machines creating a control channel require an overlap between 8 cm to 10 cm. For extrusion welding an overlap of 4 cm is the limit.

→ The outside temperature has to be taken into consideration. During periods of high temperature the elongation of the geomembrane can be important. In hot climates therefore it is recommended to execute the welding operation early in the morning when the geomembrane has cooled down during the night.

Thermal dilatation of different materials:

PVC-P: Displacement of 48 cm for 100 m length with 50°C Temperature change (from 20°C to 70°C)

HDPE: Displacement of 120 cm for 100 m length with 50°C Temperature change (from 20°C to 70°C)
Ref : Congdon, 1998



Unrolling and placing of geomembrane

c) Welding on Site

The quality of welding depends on the following parameters:

- Cleanness of the welding area (cleaning with a dry, clean cloth)
- Good adjusting of the machine (temperature, speed and pressure)
- Qualification of the workers.

The machines used are hot wedge or hot air machines. These types of machine are suitable for all kinds of materials (PVC, PP, PE)
Hand welding for the execution of details, connections at the ends of panels, based on hot air, can only be applied with PVC and PP.
Extrusion welding is the common technology for the execution of details for PE geomembranes.

d) Action of the Wind

The geomembrane has to be ballasted after installation. Wind can displace and lift the panels. In general sand bags or old tires are used as ballasting material.

In case of a protected system it is recommended to execute the protection works after the complete control of the executed section.



Welding with hot air and double seam

Fixation of the Waterproofing System

The number of fixations depends mainly on the size of the canal and on the speed of water-flow.

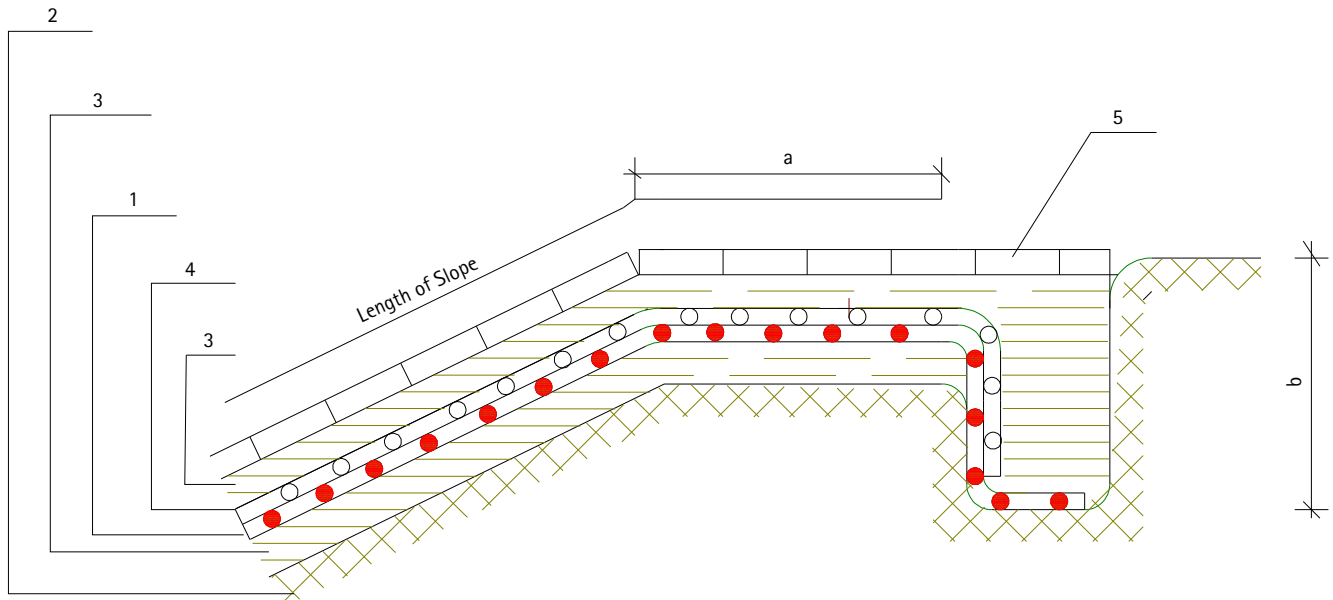
Anchorage of waterproofing system on the crest

In general the waterproofing system is anchored in a ditch. The ditch should be immediately refilled as the lining system is introduced into the ditch. The dimension of the ditch depends on the length of the slope.

In the past many concrete canals were constructed and often only a mechanical fixation to the waterproofing system is possible.

This can be achieved

- or through a colaminated metal sheet (steel sheet coated with a PVC membrane) that is cut into strips of 5 cm wide, screwed to the concrete, on which the geomembrane is welded;
- or with a stainless steel plate screwed into the concrete.



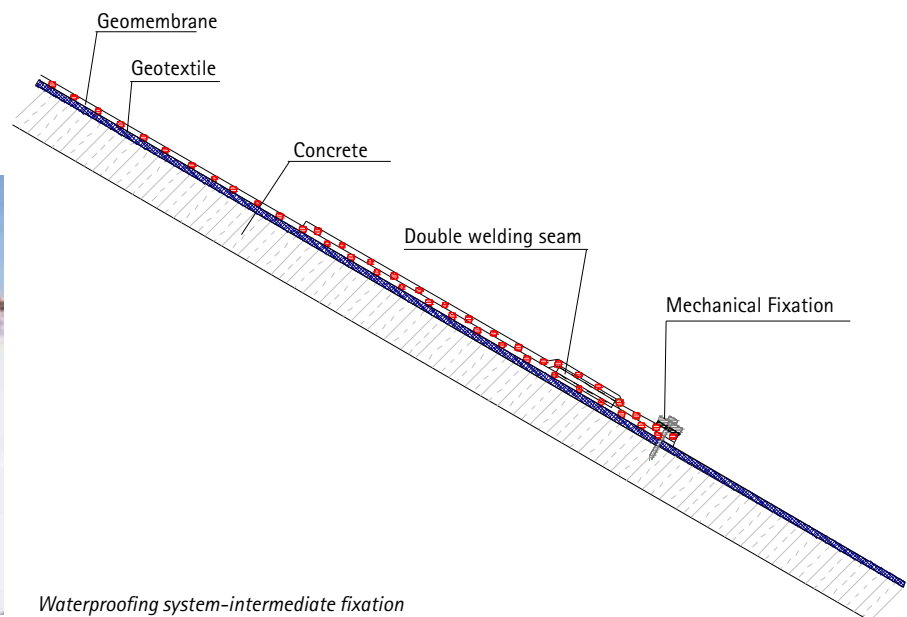
Dimension of Anchor Ditch (Principal Drawing)

1. Geomembrane RENOLIT ALKORPLAN
2. Compacted Subsoil
3. Sand as Protection Layer
4. Geotextile
5. Concrete Slabs

Length of Slope	a	b
< 10 m	> 0,5 m	> 0,5 m
10 - 40 m	> 0,8 m	> 0,6 m
> 40 m	> 1,0 m	> 0,8 m

Intermediate Fixation of Lining System

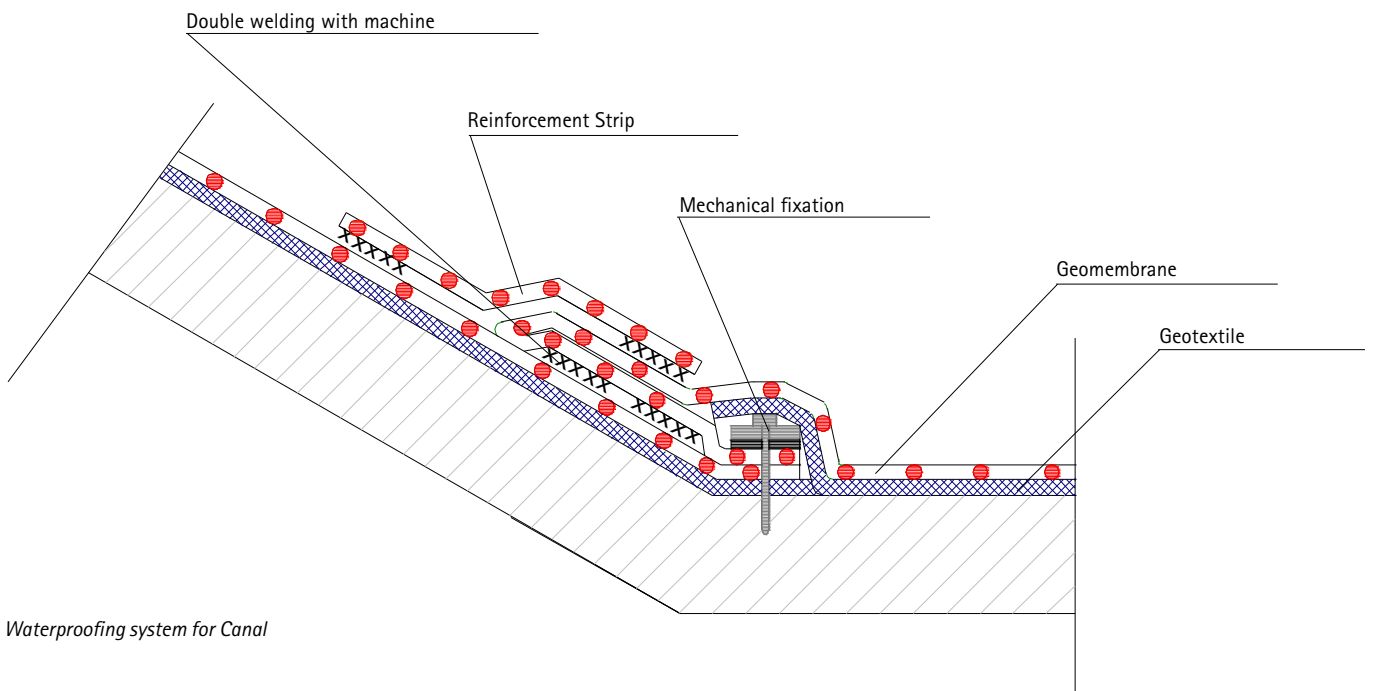
Depending on the size of the canal an intermediate fixations could be necessary. In case of very long slopes it is recommended to foresee such a fixation in order to reduce the stress on the membrane due to wind forces.



Waterproofing system-intermediate fixation

Anchorage of waterproofing system on bottom of construction

This fixation is necessary as it separates the slope from the bottom and guarantees the form of the waterproofing system.

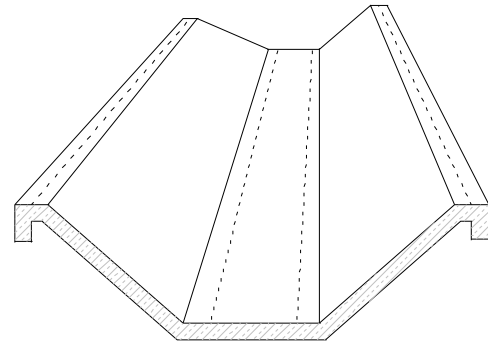


Waterproofing system for Canal



Anchorage at the beginning and at the end of the waterproofing section

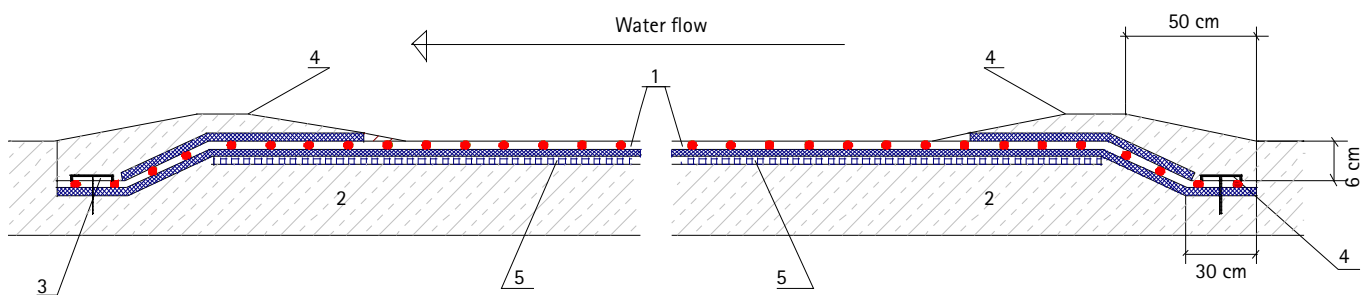
The concrete of the canal bed is not always in bad condition and therefore only the worst parts of the canal receive layer of waterproofing. Here it is important to avoid running water flowing underneath the waterproofing system, especially if no drainage layer is installed.



System for Fixation

Fixation of the lining system in the beginning and end of canal

1. RENOLIT ALKORPLAN Geomembrane
2. Existing concrete construction
3. Fixation of geomembrane with metalsheet or PVC hard plate 1,5 mm x 50 mm
4. Protection concrete for fixation
5. Drainage layer



Protection of waterproofing system

Protection against mechanical influences is a warranty for a long-lasting waterproofing system. For the following cases listed below a protection of the waterproofing system should be installed:

- in canals with a speed of water > 1 m/sec
- in areas of the project with speed of water > 1 m/sec
- against floating objects
- in areas with an access ramp
- on the bottom if cleaning with engines is foreseen
- against vandalism
- against the influence of UV radiation in exposed zones

Protection with Granulates

In order to carry out a study on the stability of the protection factor a complete knowledge is required about the characteristics of all the materials used, either granulates or synthetic, that will be used. Especially the angle of friction between the different faces may change in an important way with the type of geomembrane, the geotextile and the granulation. Therefore it is recommended to carry out trials on site to find out the best combination.

The speed of water low has to be taken into account to avoid any erosion of the protection layer.

To determine the thickness of geomembrane and the weight of geotextile the following needs to be taken into account:

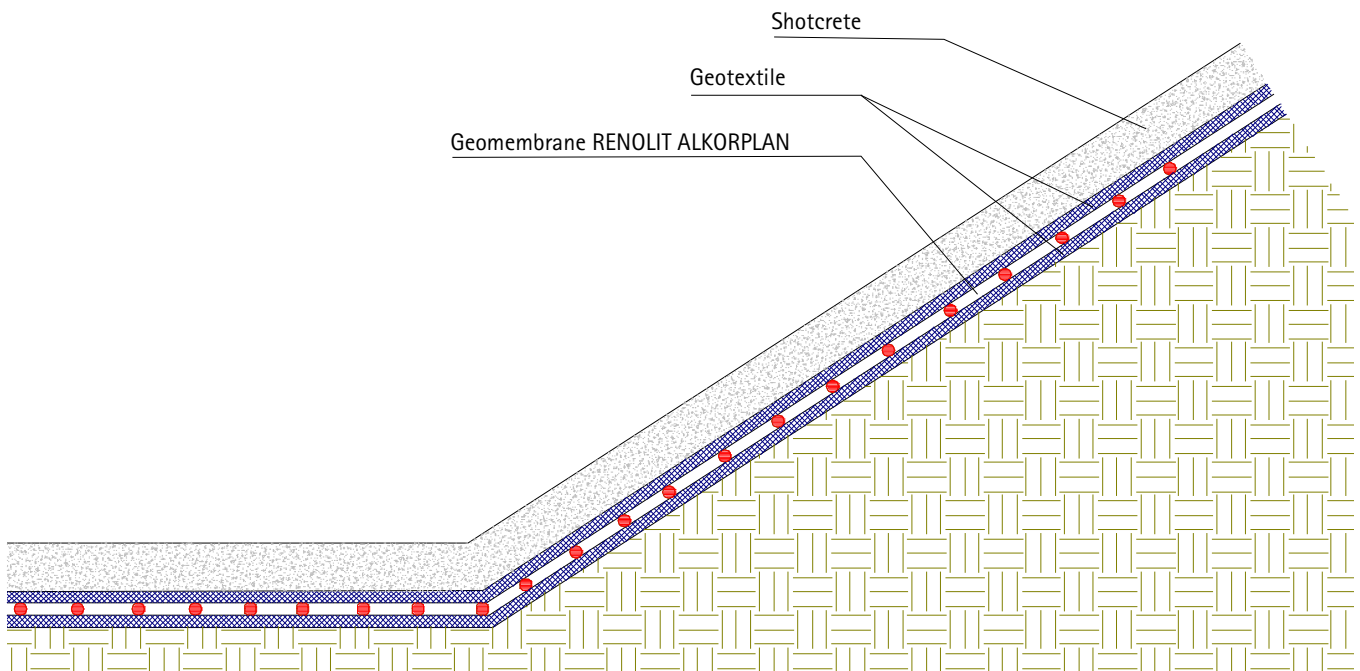
- type of geomembrane
- granulation and angle of the underground
- granulation and angle of the sub grade
- forces created during the fitting of the of the protection layer

These forces depend on:

- thickness of the protection layer placed directly onto the waterproofing system
- type of engine used for the placement of the protection layer.

Protection with concrete or shot-crete

For slopes where no stability with granulates can be achieved (angle of friction too low) a protection with concrete is the alternative.



*Waterproofing System with Shotcrete as Protection
Possible system of protection with concrete*

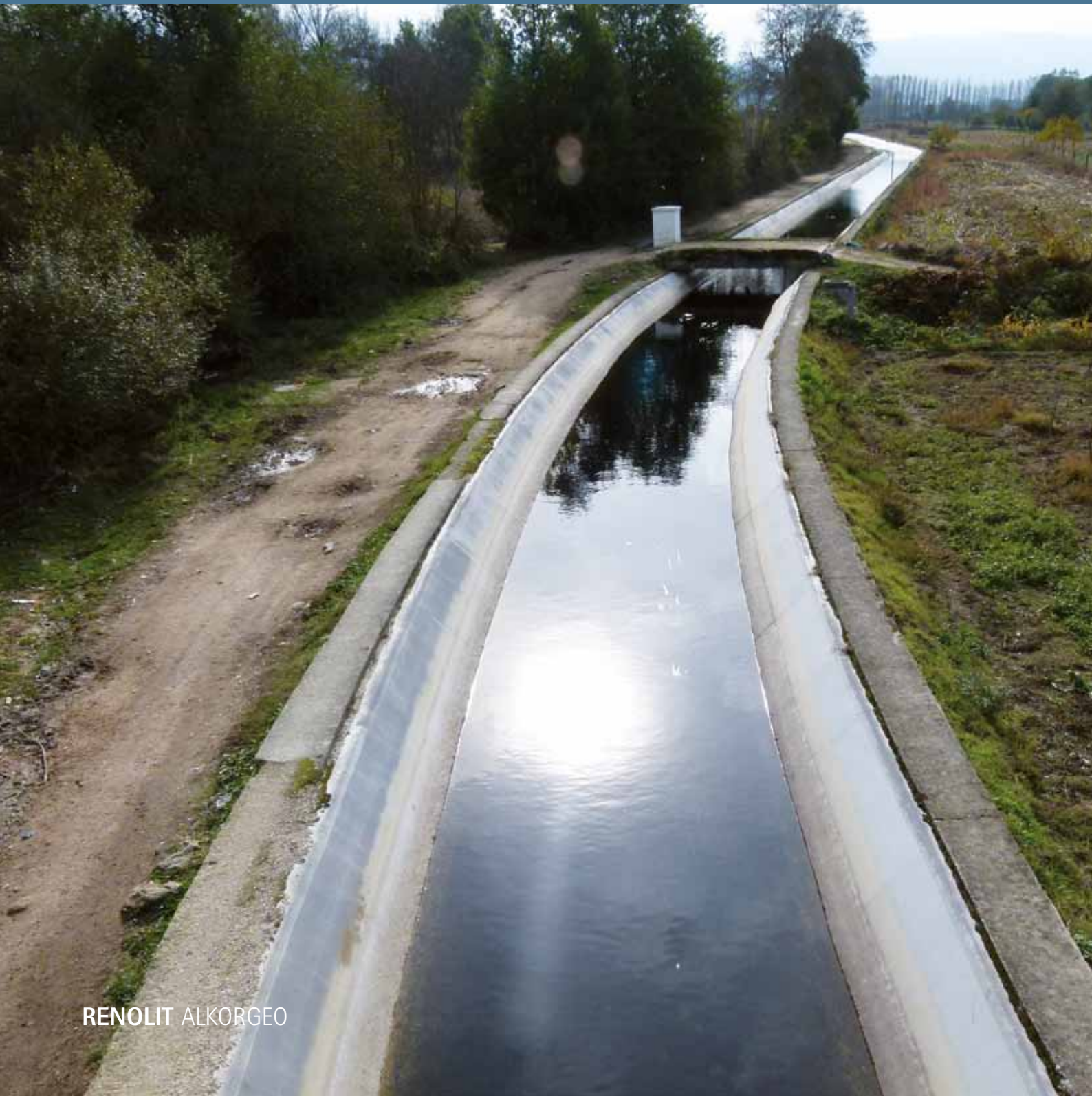




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