Drytech™
Waterproofing System Engineering

DESIGN
OF WATERPROOF STRUCTURES

Choose and design the waterproofing system

The SIA standard and good practices recall three principles for the construction of an efficient waterproof structure:
- **the Design.**
- **the Duration, which must coincide with the life cycle of the work.**
- **Maintenance, which must be less expensive than the work.**

Drytech promotes the application of these principles to improve the quality of waterproof structures and customer satisfaction with the architects, engineers and companies that design and build them.

Design as a waterproof factor

Proper waterproofing design reduces infiltrations by 60.5%.

To design a well-sealed basement, the structure and its waterproofing must be designed together.

It is therefore appropriate:
- rely on the engineering consultancy of a partner specialized in waterproofing, involving him from the design stage.
- acquire specific training in Waterproofing Design.

Requirements for waterproofing and choice of waterproofing

Not all works require watertightness.
But all works in waterproofing class 1 (completely waterproof) must adopt watertight systems.

Waterproofing systems are divided into two groups: watertight ones and those with drainage.

There is a classification of the required level of impermeability or permeability permitted for a partially or completely underground work. This data, described in the Convection of Use, is a determining criterion in the choice of the waterproofing system.

Duration of waterproofing equal to the duration of the work

The waterproofing must last for the entire life cycle of the work.
It is an obvious concept, yet not always taken into consideration when choosing the system to be adopted.
In addition to the quality and consistency of the materials, the waterproof seal is guaranteed by the real possibility of maintenance.

Maintenance cost lower than the cost of the waterproof structure

The project cost of any maintenance must always be lower than the cost of the waterproof structure.
It must be more convenient to restore it than to abandon it.

In addition to the restoration method, the cost of maintenance is affected by the accessibility to the waterproofing system and the impact on the use of the work.

For the tunnel of an important road artery, for example, it is of paramount importance that the maintenance can be perfected without blocking traffic.

Andreas Krattiger
CEO Drytech Group

History of the development of a sector without vocational training and apprenticeships from 1963 to 2021.

1963-1983 The underground and water structures are waterproofed with rigid cement systems and bituminous membranes combined with injections with acrylic and polyurethane resins for infiltrations and cracks with thermal movements.

1983-2003 Development of new systems with bentonite products, resins and synthetic membranes.

2004-2009 March 2004 the EMPA 201'043 - 202'248 report analyzes the durability and impermeability over time of 6 waterproofing systems, applied to 63 tunnels built in the open air (and subsequently buried) of which 35 above the water table with drainage systems and 28 under the water table with watertight concept, of which 70% are white tanks.

The report identifies 323 construction defects, of which:

- 60.5% originated from design errors (cracks and shrinkage cracks);
- 24% from material defects or inadequate choice of systems;
- 15.5% from execution errors.

The 63 objects are divided into waterproofing classes and waterproofing concepts, according to the classification currently in force and regulated by SIA 272.

2009 The SIA 272 standard is updated which in the cfr. 2.2.1 prescribes: *"The waterproofing measures to protect the work and ensure its full use must be defined already in the design phase. In this context, the waterproofing concepts and systems will be planned and implemented according to the specific conditions of the work."*

2009-2021 The results of the EMPA report show that the white tank is the most efficient system in the presence of water pressure. However 40/50% of the tunnels show infiltrations by bypassing the joint systems and through the cracks, which must be repaired by means of resin injections.

This highlighted the need to waterproof even the details for the entire thickness of the structure.
Although SIA 272 establishes in paragraph 3.1.3.10 that: *"Waterproof concrete structures do not require surface waterproofing layers"*, starting from 2010, sheaths adhering to concrete were offered to the market to seal cracks and counteract the circumventing effects of joint systems that do not waterproof for the entire thickness of the structure.

Various experiences in internal Switzerland have shown that the adhesion of the sheath is heavily compromised by the stagnation of the mixing water of the concrete, which creates a cement grout in contact with the sheath.
This reduces the traction force on adhesion and forms an infiltration layer that allows water to reach the cracks and water-repellent parts of the concrete, which must then be restored with resin injections.

Conclusions The sheaths don't allow maintenance and have not resulted in the desired quality improvements. For this reason we only carry out structural waterproofing, as prescribed by SIA 272.

Design of
Waterproof structures

Waterproofing should be planned already at the design stage.

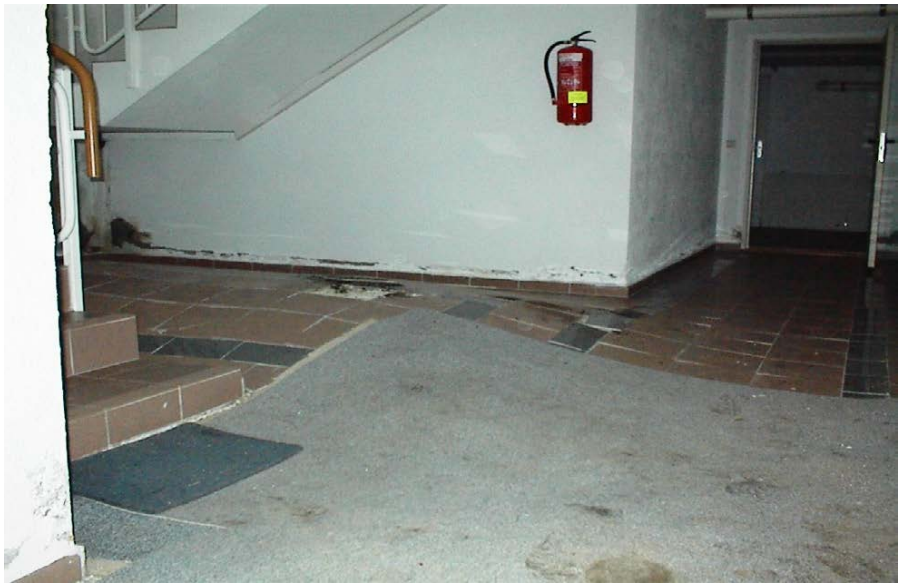
Drytech has been dealing with waterproofing since 1963. We have been offering the White Tank for 35 years and for 20 years our customers, architects and civil engineers, have received design consultancy and a guarantee on the Drytech Tank System.

By involving ourselves in the design phase:

- you entrust the responsibility for the waterproofing of the structure to an expert in the sector, while you obviously maintain the control of the static.
- you enrich your project with the Drytech point of view on the waterproof seal.
- you receive the documents for the design of the specific object, in compliance with the Standard and with cost optimization.
- you receive the descriptions for the construction company to be included in the construction specifications, in order to faithfully translate into reality what was established in the project.
- you guarantee yourself the serenity of a safe waterproofing and the control over actual costs, with no surprises during construction.

The SIA 118 standard recommends a guarantee for waterproofing from 2 to 5 years.
Drytech offers a 5-year warranty that can be extended for a further 5 years because the Drytech Tank offers real possibilities of maintenance, practical and economically sustainable.

We didn’t invent rain, but we can be your umbrella.



Waterproofing Design Training

Drytech offers updating seminars on waterproofing for architects and engineers to deepen the principles, risks and advantages of an area of building design that is certainly niche but which has an impact on the entire work.

Seminar on the behavior of concrete cracks.

- Solutions to reduce the risk of cracks.
- Controlled shrinkage waterproof concrete technique.
- Experiences with adhesion sheaths.

Duration: 30-45 minutes + final discussion.

SIA 272 compliant White Tank Seminar

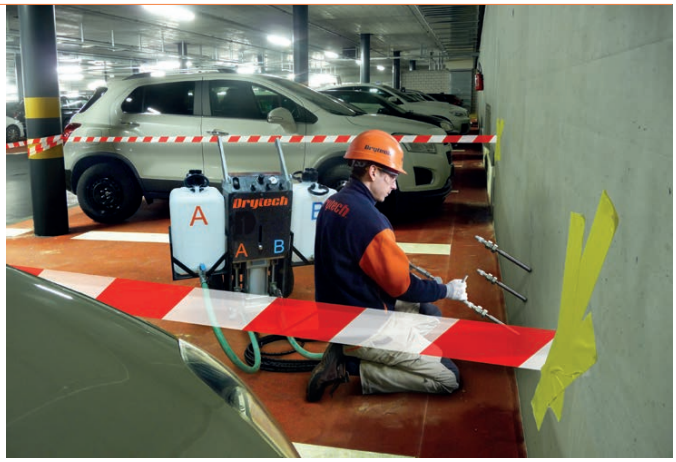
- Design of a waterproof structure in groundwater.
- SIA 272 standard.

Duration: 30-45 minutes + final discussion.

Restoration Seminar

- Remediation of infiltrations by means of injection techniques.
- Regulations on the testing of injection materials.
- Surface restoration with synthetic resins.

Duration: 30-45 minutes + final discussion.



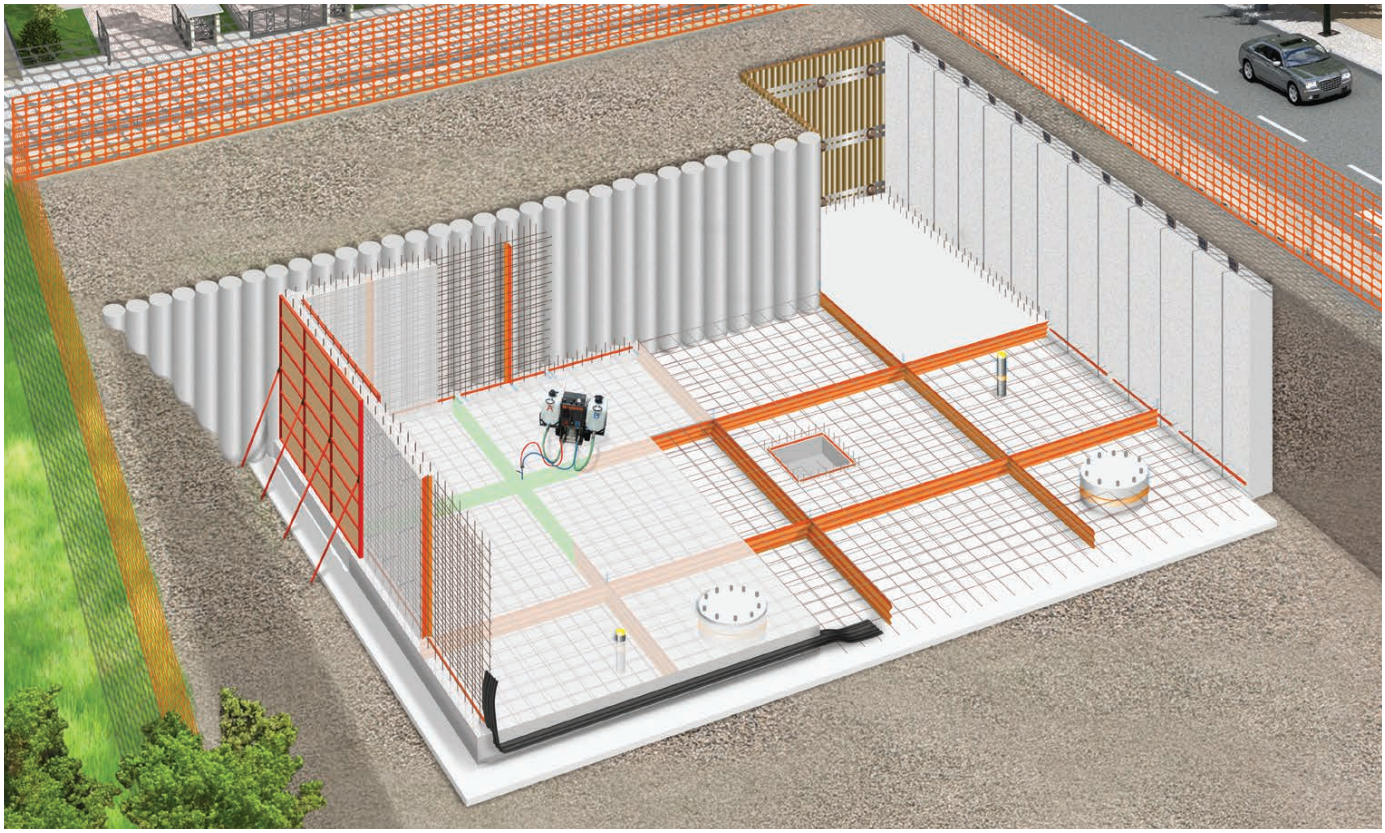
Seminar participants receive the Handbook for the Design of Waterproof Structures.

Drytech Relevant Rules 1:2020 compliant with SIA 272:2009

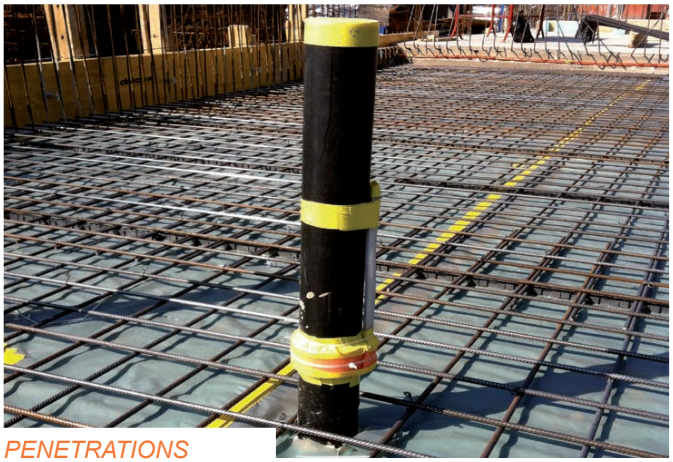
SIA 272 defines the bases for waterproofing the basements in a general and regulatory manner.
The Drytech R.R. 1:2020 comply with the SIA Standards, deepening the interpretation of some points in a clear and unequivocal way and providing additional information on risks and rules, with the aim of guaranteeing the client greater transparency and allowing him to operate in full compliance with the Standard, speeding up the project, improving the quality of waterproofing and reducing construction and maintenance costs.

To design a White Tank in compliance with SIA 272 it is necessary to comply with the bases defined in a general and normative way by the related standards:

SIA 260:2014	Basis for the design of load-bearing structures for which the waterproofing design is required, the duration of use and the possibility of maintenance must be provided to allow the service life of the structure. **As required in SIA 272 paragraphs 2.2.1 and 2**.
SIA 180:2014	Thermal insulation, moisture protection, indoor climate and building ventilation.
UFSP 2018	Radon Operating Manual 1.2018 UFSP Bern.
SIA 261:2014	Actions from the subsoil on load-bearing structures and hydraulic pressure.
SIA 267:2013	Geotechnics - structural analysis of the foundation soil.
SIA 206:2013	Concrete - Specifications, requirements, manufacturing and compliance.
SIA 262:2013	Waterproof concrete constructions, installation and curing.



CRACKING CONTROL



PENETRATIONS

JOINTS

DRYFLEX INJECTIONS

Drytech Relevant Rules 1:2020 compliant with SIA 272:2009

Esigenze

SIA 272 / 2.2.2

Tabella 2 Classi di impermeabilità

Classe		Descrizione
1	**Completely dry**	No damp spots are tolerated on the intrados of the work.
2	**Dry to slightly damp**	Insulating moisture stains are tolerated, drips on the intrados are not allowed.
3	**Damp**	Moisture stains, insulate and drips on the intrados are tolerated.
4	**from damp tu wet**	Isolated wet spots and drips are tolerated.

SIA 272:2009 - Waterproofing concepts

SIA 272:2009
paragraph 2.3.2

Draining concept

Waterproofing systems applied on the entire underground surface, which however do not seal the section of the structure, so the risks from circumventing and capillary effects must be taken into account. They must be combined with water flow diversion and drainage systems that ensure the absence of stagnant and pressurized water. Flow diversion systems must be capable of periodic maintenance.

Drytech R.R. 1:2020
paragraph 8

Notwithstanding
SIA 272 paragraph 2.3.3

Watertight concept proposed by Drytech

With the watertight concept, groundwater, meteorological, surface and mountain waters are not drained.
The systems are waterproof over the entire underground surface and seal the entire thickness of the structure, in which injected systems are inserted, with the possibility of carrying out maintenance by means of re-injectable systems from the accessible side of the structure itself.

SIA 272:2009
paragraph 2.4.3

Risks inherent in the systems

In choosing the system to be adopted, the risks associated with it must be duly taken into consideration and the possibility of maintenance must be foreseen according to the specific conditions of the structure.

Risk assessment includes:

- Waterproofing inaccessible on their perimeter or section once the works are completed and, therefore, which cannot be accessed for maintenance work. For example, underground constructions or rock tunnels.

- Waterproofing that remains accessible and that can be maintained and remediated, such as accessible tanks, reservoirs and pipes.

In the event that the waterproofing system does not perform its function adequately, an alternative solution must have been foreseen, duly studied and planned already in the design phase.

Examples of maintenance for drainage systems

Periodic checks of the diversion paths of water flows and drainages. In the event of infiltration, injection systems must be adopted. Systems not designed for restorarion injection can make maintenance burdensome, so they should not be taken into account and avoided.

Examples of maintenance for watertight systems

To seal the thickness of the concrete, must be used injection profiles for resins that allow re-injection.

To allow the maintenance of underground systems, it will be necessary to ensure accessibility from one side of the structures. If, on the other hand, the waterproofing system is inaccessible, the risk and burden of any removal to allow maintenance must be described in the Usage Convention.

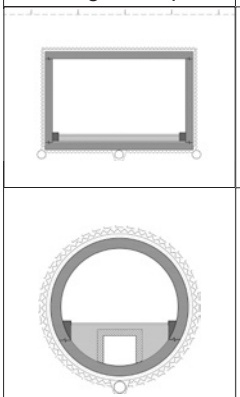
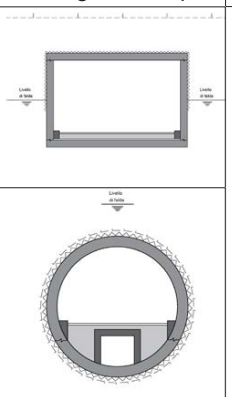
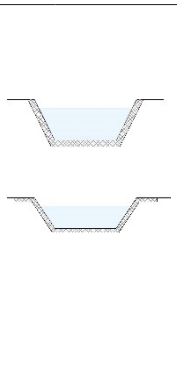
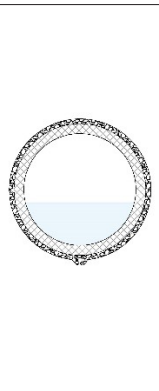
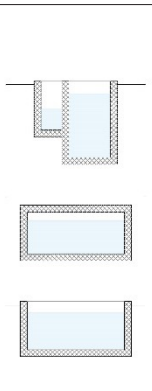
SIA 272:2009
paragraph 2.4.4.

System choice

The choice of the system is dictated by the Usage Convention (Chapter 2), by the type of foundation soil (behavior to deformation, hydrogeological and geological conditions), by the type of filling materials, by sudden changes and thermal influences, by liquid substances and not contained in the water, by the influences coming from the specific conditions of the work and ecological.

Drytech R.R. 1:2020

Recommended waterproofing concepts

Table 12	Examples of application of the waterproofing classes to be included in the Use Agreement.				
Application examples	Underground structures and open-air tunnels Draining concept	Underground structures and open-air tunnels Watertight concept	Underground tanks and channels	Rock tunnels	Water structures, purifiers, aqueducts and swimming pools
					
Waterproof class	2	1	1, 2 o 3	1 o 2	1 o 2

Drytech Relevant Rules 1:2020 compliant with SIA 272:2009

Waterproof concrete

Waterproof concrete can be of guaranteed performance or composition, with controlled hydraulic shrinkage behavior.

SIA 272:2009
paragraph 3.1

Requires a maximum infiltration depth of ≤ 50 mm according to SN / EN 12390-8.
For the calculation of the physics of buildings it requires to take into account a water diffusion of 10 g/m² x h.

Drytech R.R 1:2020
paragraph 15
paragraph 3.0

Requires a maximum infiltration depth of ≤ 30mm according to SN / EN 12390-8 to protect the reinforcements.
The pressure of the water and its diffusion always takes place from the warmer side to the colder side.

SIA 272:2009
paragraph 3.1.3.4

The cracks can be permeable starting from a width of 0.1 mm.
The allowable tension of the rebar for limiting the nominal opening of the cracks at the time of the formation of cracks is:

$$\sigma_{adm} = \sqrt{\frac{9 \cdot Es \cdot f\,ctm \cdot W\,nom}{\emptyset s}} \leq f\,sd$$

Waterproof class 1 = ≤ 0.1 - 0.2 mm
Waterproof class 2 = ≤ 0.2 - 0.4 mm
Waterproof class 3 = ≤ 0.4 - 0.7 mm

A reduction of these amplitudes is possible if the shrinkage and sliding of the foundation plinth on the support are not hindered (absence of frictional forces) and if there are planned cracking elements and simple static models, including joints waterproofed so adequate.

Drytech R.R. 1:2020
paragraph 7.8

In compliance with SIA 272 paragraph 3.1.3.4, R.R. Drytech 1:2020 paragraph 7.8 provides for a reduction in Af nom (nominal gap width) considering that, depending on the hydraulic pressure, widths of 0.05 mm can cause water infiltration.

Drytech R.R. 1:2020
table 9

Hydrostatic pressure and influence on cracks
It illustrates how the water pressure in the normative calculation SN EN 1992-1-1:2005 affects the permeability of cracks and shows the calculation result.
Af = admissible limit state of crack width.

Influence of hydrostatic pressure on cracks

SN/EN 1992-1-1
Drytech R.R. 1:2020

Depending on the hydraulic pressure, the cracks can cause water infiltration starting from a width of 0.05 mm.

Waterproof class 1	Expected nominal width of the slots from 0.05 to 0.2 mm
Waterproof class 2	Expected nominal width of the slots from 0.2 mm to ≤ 0.3 mm
Waterproof class 3	≤ 0.5 mm

Table 9
Compliant SN/EN 1992-1-1

Admissible limit state in mm of width of cracks in Concrete C 30/37 = Tensile strength 2.9 N / mm^2 for slab and walls.

Waterproof class 1 — Calculation examples

Water table pressure m/h	Concrete thickness up to 150 cm	Concrete thickness up to 100 cm	Concrete thickness up to 80 cm	Concrete thickness up to 60 cm	Concrete thickness up to50 cm	Concrete thickness up to40 cm	Concrete thickness up to30 cm	Concrete thickness up to 25 cm
1 m								Af 0.200
2 m						Af 0.200	Af 0.192	Af 0.185
3 m				Af 0.200	Af 0.195	Af 0.188	Af 0.175	Af 0.165
4 m	Af 0.200	Af 0.200	Af 0.200	Af 0.192	Af 0.185	Af 0.175	Af 0.163	Af 0.142
5 m	Af 0.200	Af 0.200	Af 0.194	Af 0.183	Af 0.175	Af 0.163	Af 0.142	Af 0.125
10 m	Af 0.192	Af 0.175	Af 0.163	Af 0.142	Af 0.125	Af 0.100	Af 0.058	Af 0.050
15 m	Af 0.175	Af 0.150	Af 0.131	Af 0.100	Af 0.075	Af 0.050	Af 0.050	
25 m	Af 0.142	Af 0.100	Af 0.069	Af 0.050	Af 0.050			
35 m	Af 0.105	Af 0.050	Af 0.050					
50 m	Af 0.052							
> 52 m	Af 0.050							

Estimates processing

Handbook for the Design of Waterproof Structures

You can ask info@drytech.ch for your personal copy of the Manual for the Design of Waterproof Structures.

Documentation for offers

For the preparation of estimates, you can send your requests to info@drytech.ch, attaching:

- Geological survey.
- Channeling plan.
- Information on the penetrations of the structure of electrical and geothermal plants.
- Structural plans with complete sections and indication of the ground levels and maximum stagnation planned.

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Waterproofing System Engineering

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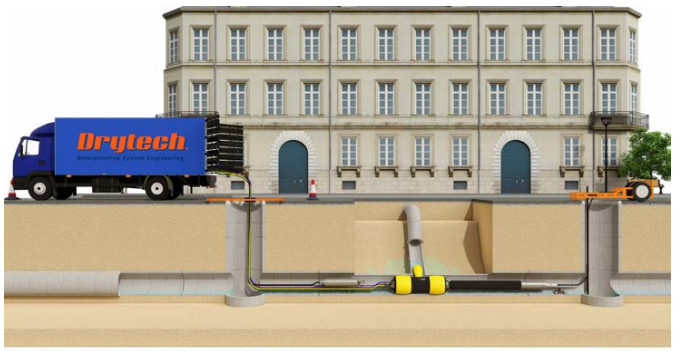
New

Canalization restoration

Waterproofing injections of canalizations with remote-controlled robots.

- Quick and non-invasive
- Result immediately verifiable with cameras and air under pressure.
- Without excavations or demolitions.
- Absolute novelty for Europe.



Drytech waterproof concrete with 35% recycled asphalt material

- More available, economical, practical and less energy-intensive recycling material.
- Certified and guaranteed technical conformity.
- Does not require greater dosages of cement.
- Resource saving.
- Circular economy.