

WACKER

CREATING TOMORROW'S SOLUTIONS

ETONIS®

CONSTRUCTION | CONCRETE | ADDITIVES

ETONIS® – JUST ADD PERFORMANCE
OPTIMIZING CONSTRUCTION WITH
MODIFIED CONCRETE

FOR SUPERIOR PERFORMANCE IN CONSTRUCTION: MODIFIED CONCRETE

Concrete for stadiums, freeway interchanges, or bold bridge designs – no other material is as versatile and economical. Thanks to intense research over the past few decades, the property profiles of today's concrete grades have opened up entirely new applications in the construction industry. Over the last decade, ETONIS® concrete admixtures have contributed to this development too.

Redefining the Limits of Possibility

Polymeric binders open up new design options for architects and planners. Extra-lightweight, curved components made of architectural concrete, water-absorbent roads and plazas – projects that would have been unthinkable until just recently but that are now feasible in high quality thanks to polymer binder modifiers.

Increasing Building Longevity

Today we can improve the performance and longevity of concrete far beyond what was possible in the past. That, in turn, impacts the quality of the building fabric: modern modified concrete raises the service life of a building by far.

Building for Greater Sustainability

Today's infrastructure projects are drawing more attention than ever before. The focus is now no longer on cost alone – project sustainability is important too. Modified concrete has benefited greatly from this trend: Modifying materials, after all, reduces the amount of cement used, which prevents unnecessary greenhouse gas emissions.

Polymer binder from WACKER are revolutionizing the construction industry to this day.

1938

Large-scale production begins for vinyl acetate – the starting material for all of WACKER's concrete additives.

1960

The discovery of vinyl acetate-ethylene (VAE) polymers establishes a new generation of liquid modifiers.

1985

Production of the first dispersible polymer powders based on VAE.

2008

Our test series with polymer-modified sprayed concrete begins at the Hagerbach Test Gallery, with a focus on tunnel construction.

2015

Demand for polymer dispersions grows. The largest spray dryer for VAE dispersions in North America goes on-stream in Calvert City, Kentucky (US).

2018

We supply innovative modifiers for the global construction industry from our five polymer chemistry sites in Germany, the US, China and South Korea.

WACKER is now the global leader in polymer dispersions and dispersible polymer powders based on VAE.

ETONIS® is a registered trademark of Wacker Chemie AG.





DISCOVER THE ADVANTAGES OF ETONIS®

ETONIS® additives have a doubly positive effect on concrete: They improve the behavior of fresh concrete and optimize the qualities of hardened concrete.

Improved Workability

Addition of ETONIS® makes fresh concrete more pliable, which has a positive effect on its flow properties, pumpability and sedimentation stability.

Higher Elasticity

In hardened concrete, ETONIS® lowers the modulus of elasticity while keeping compressive strength high, making concrete ductile, even though it is concrete. In actual construction applications, this translates to higher tensile and flexural strengths, greater elongation at break and reduced susceptibility to tearing – advantages anytime absorbing thermal stress, vibrations or pressure is important.

Highly Resistant

In solid concrete, ETONIS® provides outstanding anti-abrasion properties, along with excellent resistance to chlorides dissolved in water. ETONIS® modified concrete also acts as a protective shield against acids, gases and other aggressive media.

Better Adhesion

ETONIS® improves cohesion and adhesion in concrete, even bonding on damp substrates or smooth surfaces like metals.

One Innovative Technology – Many Applications

Development over the past decade of ETONIS® concrete admixture has been significant. What began as a polymeric binder for considerable sprayed concrete applications is now available for all types of concrete construction – from road stabilization and pervious concrete to self-filling and fiber-reinforced concrete.

Road Stabilization and Dust Suppression

ETONIS® 1000 S 6

Water Containment and Tunneling Works

ETONIS® 3000 W 10

Concrete Protection and Refurbishment

ETONIS® 5000 P 16

Specialty Infrastructure Applications

ETONIS® 7000 A 22

Structural Material

ETONIS® 9000 M 30



ETONIS[®] 1000 S ROAD STABILIZATION AND DUST SUPPRESSION

A mixture of cement and ETONIS[®] provides effective stabilization for the subgrade courses underneath roads. This technology is not only of interest for gravel paths, but also extends the service life of asphalted roads.



Simple and Cost-Effective

Thanks to a new soil stabilizing technology, it's never been easier to rehabilitate country roads without pushing the boundaries of your budget. Instead of excavating the subgrade and replacing it with new material, the entire road substructure can be recycled. The solution: a soil stabilizer containing polymer-modified cement based on ETONIS®. Even high-traffic forest service trails and access roads can be repaired quickly this way – at lower cost than is the case with foamed asphalt. Comparisons show that road rehabilitation costs can be reduced when ETONIS® is used.

Highly Durable

Adding ETONIS® increases the overall flexibility of the stabilized subgrade while making it resistant to mechanical loads and frost. It also improves shear strength, making roads suitable for use by heavy equipment.

Longer Service Life

Polymer modification of the substrate increases maintenance intervals and keeps roads stable three times longer than is the case with a traditional hydraulically bound base course.

Advantages of ETONIS® 1000 S ...

... when fresh

- Polymer can be applied directly onto the surface with no risk to the environment

... when hardened

- Highly resistant to frost, erosion and wear
- High degree of compaction keeps aggregate from shifting
- Improved shear strength

BAVARIA, GERMANY

FROM FARM TRACK TO ROAD

In 2017, a farmer in Bavaria was looking for a way to stabilize the track he used for accessing his fields – a track that was routinely destroyed by his farm equipment and frost. A treatment with a subgrade stabilizer including ETONIS® remedied the situation. Today, his vehicles move on a load-bearing roadway. Due to the polymer-modified cement reinforcement, the frequency with which he has to repair the track has decreased significantly.





“Treating an unpaved road with a soil stabilizer can triple its service life.”

Nikolaus Bucksch,
Marketing Manager,
WACKER POLYMERS

Stable, water-resistant, dust-free roads with polymer-modified subgrade stabilizer

The first step is to scatter a defined layer of cement on the unpaved road surface. The construction equipment then grinds up the surface at the specified depth. In the process, the road material is mixed with the previously applied cement and the ETONIS® polymer binder. The polymer acts as a binder and builds bridges between the soil and cement particles for a flexible and strong pavement.

Once the roller has compacted the substrate and the grader has leveled the roadway, an additional layer of ETONIS® polymer binder is sprayed onto the surface to stabilize the wearing course and increase durability. Alternatively, it can be covered with a layer of asphalt. The increased flexibility of the subgrade means that a thinner layer of asphalt can be applied.



The concrete is compacted along the full cutting depth. The system even reliably incorporates large aggregates – the perpetrators behind the development of pot holes.

ETONIS® 3000 W

WATER CONTAINMENT AND TUNNELING WORKS

Difficult substrates showcase the strengths of polymer-modified sprayed concrete, which adheres to materials that push traditional concrete to its limits. At the same time, it also reduces rebound – and thus construction time and expense.

Fast, Economical Construction

What really sets sprayed concrete enhanced with ETONIS® apart is the fact, that it adheres very well to smooth substrates, such as metal and wet rock. Nothing slides off, even when layers more than 10 centimeters thick are applied. Depending on the polymer content, the concrete formulation and the spray method used, rebound can be reduced by more than half – in one case even as much as 71% reduction was measured. This generates a wide range of economic benefits:

- Less material and a shorter application time
- Less waste material and lower disposal costs
- Longer intervals between maintenance for machinery

ETONIS® also improves pumpability, thereby reducing the risk of blockages and the resulting downtime of the pumping system.

High Strength and Density

ETONIS® significantly reduces cracking in sprayed concrete, simultaneously making it more resistant to mechanical forces, such as those found in pressure tunnels.

Improved Ductility

Concrete formulations modified with ETONIS® have a lower modulus of elasticity, while their compressive strength remains high. Their improved elasticity is an advantage wherever absorbing thermal stress, vibrations and pressure is important.

Lasting and Durable

Blends modified with ETONIS® achieve low water/cement ratios. In hardened concrete, the additive acts as a protective shield against CO₂ chlorides and sulfates.

Suitable for any Situation

ETONIS® works well both for high-volume wet spraying as well as for dry spraying for smaller volumes.

Advantages of ETONIS® 3000 W ...

... in wet concrete

- Excellent adhesion to smooth and wet substrates
- Good pumpability reduces the risk of blockages and downtimes
- Rebound reduced by 50% and more

... in dry concrete

- Low modulus of elasticity results in greater ductility
- Low water/cement ratio translates to considerable strength and prevents permeation by water
- Highly resistance to CO₂, chlorides and sulfates



MUNICH'S ISAR CANAL, GERMANY FILLING THE GAPS WITH SPRAYED CONCRETE

The Isar Canal near Munich had grown old. Repair work was needed to prevent additional damage from freeze-thaw cycles.

After field tests had been performed with various systems, modified sprayed concrete was selected. Dry spraying was determined to be the most economical choice, as only comparatively small areas needed to be treated over a stretch of 30 kilometers. With the ETONIS® admixture preblended in the dry mortar, all that was left to do was add water to the dry mix near the spray nozzle.

To achieve a good seal, the engineers added 5% ETONIS® resulting in a modified concrete that was sticky enough to adhere cut out to the wet walls of the canal.



Although the old concrete was still in good condition, there was damage to the canal in many areas.



A nozzleman applies the polymer-modified sprayed concrete.

THE RIO METRO, BRAZIL

A WATERTIGHT DESIGN

Rio de Janeiro expanded its subway system for the 2016 Olympic Games – a project for which tunnel builders turned to waterproof concrete based on ETONIS®.

Loose, sandy soils posed the greatest challenge during construction of the new Metro Line 4 between Barra da Tijuca and Gávea. For that reason, the tunnel walls were immediately stabilized with sprayed concrete during the excavation. In some places the groundwater pressure was high enough that water seeped through the tunnel walls.

A Highly Concentrated Blend

To waterproof the tunnel lining, an additional layer of polymer-modified sprayed concrete was applied to affected sections in early 2014. The blend used, contained 10 percent ETONIS®.

The method represented a technological first for the Brazilian tunnel builders. Seven days after the application of the sprayed concrete layer modified

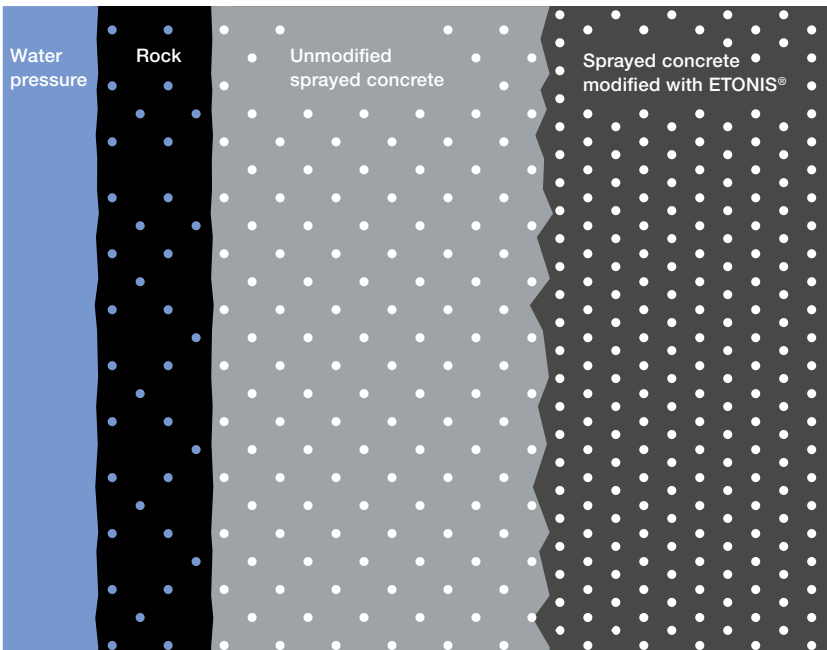
with ETONIS® the first inspection showed no more traces of the water spots that had been so numerous before. The walls of the new subway tunnel were clearly dry.

Concrete Products for Water-Polluting Substances

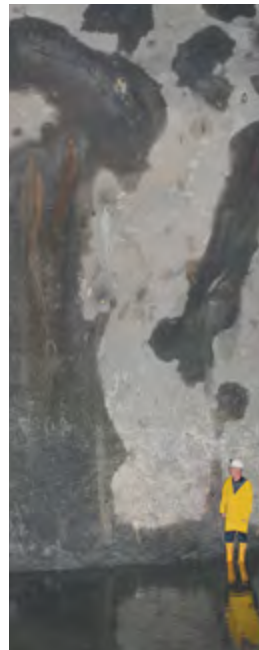
ETONIS® does more than just reliably seal tunnels – it also serves as the ideal additive for formulating liquid-tight concrete grades (with and without penetration testing as defined in the guidelines of the German Committee on Reinforced Concrete, DAfStb).

Examples of applications include

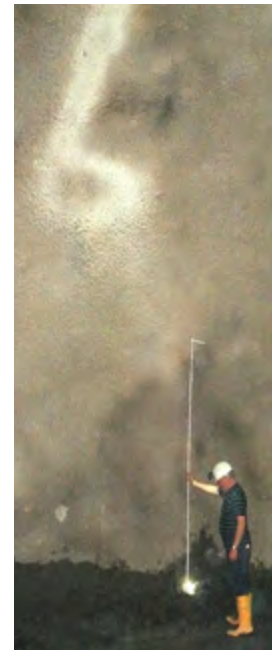
- Catch trays and basins
- Transfer stations
- Gas stations



Principle: A proven solution for waterproof tunnel linings: application of a second layer at least 5 cm thick of sprayed concrete in which the polymer content is high.



Before: Groundwater seeped through the tunnel walls after heavy rains.



After: Application of modified sprayed concrete kept the tunnel walls dry.

THE HAGERBACH TEST GALLERY, SWITZERLAND

THE SEARCH FOR THE PERFECT MIX

In 2008 WACKER began testing polymer-modified, sprayed-concrete blends under realistic conditions at the Hagerbach Test Gallery in Switzerland. The company's focus was on finding the optimum polymer content.

During these test series, WACKER applications engineers focused on rebound, compressive strength values and the depth of water permeability in wet sprayed concrete that had been modified with ETONIS® dispersions and dispersible polymer powder.

Effective Starting at Two Percent

The mixtures tested contained polymers in concentrations ranging between 1.7% and 10% relative to the amount of cement. Tests on various formulations showed that around 2% of ETONIS® modifier is all it takes to achieve sustainable, reproducible reductions in rebound in wet spraying.

Up to Two-Thirds Less Rebound

The optimum level of ETONIS® was found to be 7.5%, which reduced rebound by up to 71% over the unmodified control system. Modification with 5% or more was enough to reduce cracks and thus prevents water penetration (see following table).

Depth of Water Permeability		
	Unmodified concrete	Modified concrete
ETONIS® concrete admixture	—	5%
Water	136.5 kg	128 kg
Meyco SA 160 (% on cement content)	5%	5%
Water/cement ratio (Darr method)	0.46	0.48
Maximum depth of water permeability (maximum permissible depth of water permeability ≤ 50 mm)	26 mm	25 mm

Depth of water permeability after 3 days at a pressure of 5 bar. Polymer-modified, sprayed concrete meets all of the requirements for dense, waterproof concrete.



THE HINTERMUHR PUMPED STORAGE POWER PLANT, AUSTRIA RENOVATION IN RECORD TIME

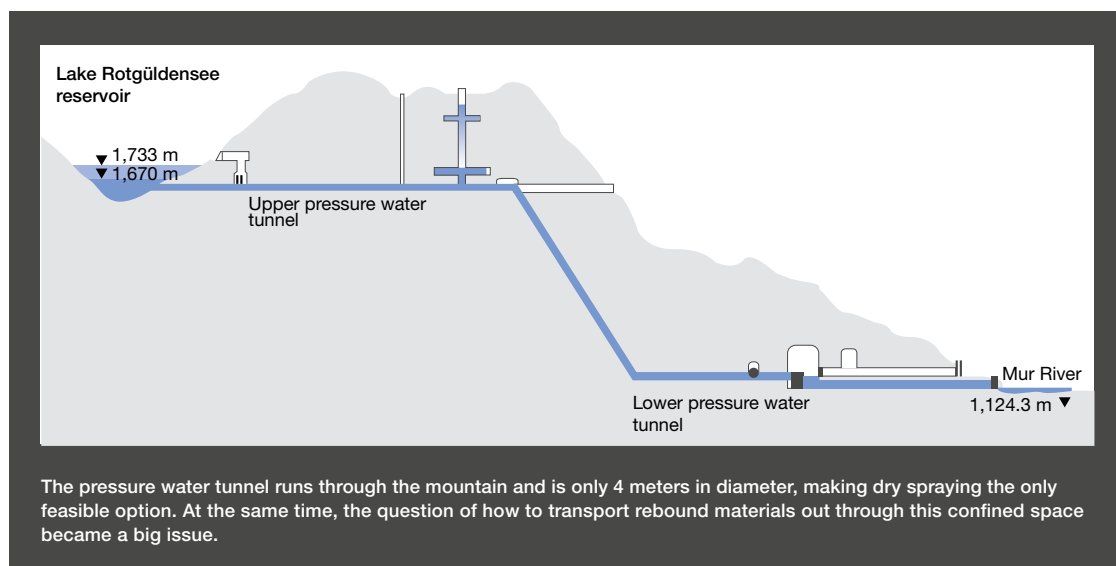
The Hintermuhr pumped storage power plant is a reliable source of electricity. It also prevents flooding in lower-lying villages. Water loss was registered in the pressure water tunnel, which called for quick repairs – the snow would be melting soon.

The primary function of the Hintermuhr power plant is to serve as a buffer. In times when energy consumption is low, water is pumped to Rotgüldensee (1,733 m), a lake lying at a higher elevation, so that it will be available for generating electricity when demand is high. In 2009, water loss was registered in the pressure water tunnel and grouting did not remedy the problem. This meant it was time for renovation work and the pressure water tunnel was drained dry in preparation. Due to the confined conditions in the tunnel, dry sprayed concrete was the only feasible option.

A 50 Percent Reduction in Rebound

Because the seal needed to be watertight, the decision was made to modify the concrete with 7.5% ETONIS®. This also had the advantage of reducing rebound by approximately 50%. As far as savings go, the amount of concrete required was 156 metric tons less than calculated. For transporting waste, only 152 hours were needed instead of the expected 308. As a result, the

renovation was completed before the snow started melting – and the remediated sections have not experienced any meaningful water loss since.



The pressure water tunnel runs through the mountain and is only 4 meters in diameter, making dry spraying the only feasible option. At the same time, the question of how to transport rebound materials out through this confined space became a big issue.

ETONIS® 5000 P

CONCRETE PROTECTION AND REFURBISHMENT

When components need to be replaced or repaired, the concrete formulation has to be high-quality. ETONIS® allows you to formulate blends that can withstand considerable mechanical stress, frequent freeze-thaw cycles and chemical degradation.

Improved Frost Resistance

The most important way of protecting reinforced concrete structures is to prevent corrosive materials from penetrating them – and water-repellent ETONIS® is perfect for the job. In hardened concrete, the additive also delivers good elasticity for bridging cracks in the substrate, and improves the performance of the mortar used for repairing relatively small areas of damage.

Excellent Chemical Resistance

The use of modified, high-performance concrete is recommended right from the start, when constructing sewers and wastewater treatment plants. ETONIS® makes pipes and catch basins highly resistant to chemical degradation.

Advantages of ETONIS® 5000 P ...

... in fresh concrete

- Hardens quickly for repair work that needs to be carried out within a short period of time

... in hardened concrete

- Water tightness of the concrete prevents the intake of ions
- Good crack-bridging properties

Comparison test:

Impact of CO₂ on modified and unmodified concrete after 56 days.

Test pieces were treated with phenolphthalein to determine the depth of carbonation. This turns alkaline areas pink, while areas that have already carbonated (pH value < 9) remain colorless.



Unmodified concrete:

The colorless area indicates concrete that has carbonated.



Concrete modified with ETONIS®:

The depth of carbonation (colorless area) is very slight in this case, which means that the steel reinforcement is extremely well protected from corrosion.



LATEX-MODIFIED CONCRETE ROADS, SOUTH KOREA

ENHANCED FREEZE-THAW DURABILITY

Winters in South Korea are cold. The risk that freezing temperatures pose to concrete roadways is correspondingly high. Modifying concrete with ETONIS® makes roads last significantly longer.

A key factor in the longevity of concrete road surfacing is its ability to withstand frequent freeze-thaw cycles. To improve crack resistance, modified concrete has been used for decades. This keeps water and deicing salts from entering the surface. Frost damage and alkali-silica reaction can be prevented. While SB latex has been the dominant additive to date, the market in Asia has begun to move in a new direction – toward vinyl acetate-ethylene (VAE).

Significantly Improved Performance

When repairing a South Korean roadway in 2016, we tested a VAE binder for modified concrete. After milling the old road surface, a new, 50 mm thick base course was installed. In the process, it has been demonstrated that the ETONIS® additive significantly increases freeze-thaw durability. Relative to concrete grades reinforced with SB latex, formulations based on VAE exhibit markedly less chloride ion diffusion. Chloride ions, such as those found in road salt, are one cause of damages.

Yet another difference became apparent when testing the new blend in South Korea: Road surfacing formulated with ETONIS® shrinks less than traditional concrete modified with SB latex, with no detectable cracks, even 30 days after the new concrete was installed.



VAE-Modified Concrete Keeps Water and Road Salts at Bay

Concrete Formulation

Water/Cement	S/A	Water	Cement	Small Grain Size	Large Grain Size	Binder	Defoamers	P/C
35%	52%	72	400	849	796	128	1.5%	15%

Test Results for South Korea

	Unmodified	Modified with VAE ETONIS®
Compressive strength (after 4 days)	27.3	27.8
Settling (initial / 30 min. / 60 min.)	230 / 200 / 195	205 / 200 / 190
Chloride ion penetration (c)	3,300	2,100
Dry shrinkage	Relatively low	Good

THE SICHUAN ZHANGJIAJIE AIRPORT, CHINA

RESTORED IN SIX HOURS

The first signs of apron damage at China's Sichuan Zhangjiajie Airport appeared in 2016. Keeping air traffic disruptions to a minimum meant having to perform repairs quickly.

In addition to the tight deadline, the concrete technology also faced unique demands posed by the high altitude of the airport. At 3,000 meters above sea level, the airport runway surfaces are exposed to harsh cold, for over half of the year. Intense UV radiation reinforces the problem.

Vulnerable Sealing Profile

The most severe damage was found in the areas around the expansion joints. This was where the elastic sealing profiles had been harmed by the elements and mechanical stress, allowing water and corrosion-promoting substances to penetrate the concrete and in some places destroy it.

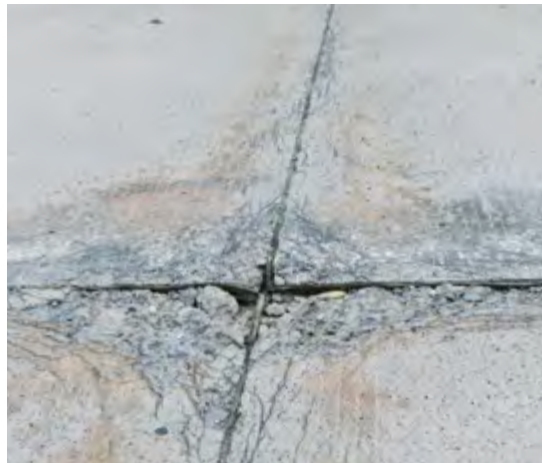
Dry After Two Hours

Keeping the cost of delays and canceled flights low meant having to repair the surfaces in a few hours. Modified repair concrete based on ETONIS® was the product of first choice, as its ability to harden quickly makes it perfect for performing repairs under heavy time constraints.

The process involved removing damaged concrete down to a depth of 10 centimeters and filling it with the repair concrete. One advantage of the modified blend is, that it ensures excellent adhesion between the repair concrete and the existing substrate. The concrete was dry in just two hours. After only four hours, the renovated surfaces could once again be approved for air traffic.

A Long-Lasting Solution

Modifying concrete with ETONIS® improves the flexural strength of the repaired surfaces. In addition to the outstanding freeze/thaw resistance of the modified concrete, the airport apron will also be better equipped to resist cracks and damage caused by the elements.



Before: The elements and mechanical stress had destroyed the concrete along expansion joints.



After: The use of modified concrete made it possible to repair the surfaces and have them ready for use again in just a few hours.



ETONIS® lowers the elastic modulus of the concrete. This improves its mechanical resistance, and prevents cracks in the road from forming as quickly.

THE GERMAN AUTOBAHN RAPID INTERVENTION FOR “CONCRETE CANCER”

In Germany, hundreds of kilometers of freeway are afflicted with a condition known as concrete cancer. In one cost-effective solution, an affected section was paved over with a concrete blend based on ETONIS®.

In 2011, the concrete on a German freeway suddenly broke up. Cracks appeared. The cause was quickly identified: An alkali-silica reaction (ASR) – also known as concrete cancer – triggered by inappropriate aggregates. The alkaline substances in the cement used for making the concrete and the alkali-soluble silicas in the aggregates react to form a hygroscopic gel that swells, resulting in network cracks, blooming and spalling.

An Economical Method

Depending on the weather conditions, ASR can cause the roadway to fail completely within a short period of time, requiring the road surface to be replaced. Using the whitetopping method, to add

a top layer of concrete, was an ideal and economical solution. The damaged surface material was ground down to the necessary depth and then covered with a thin layer of concrete – a blend that included ETONIS®, which is both highly dense and hydrophobic.

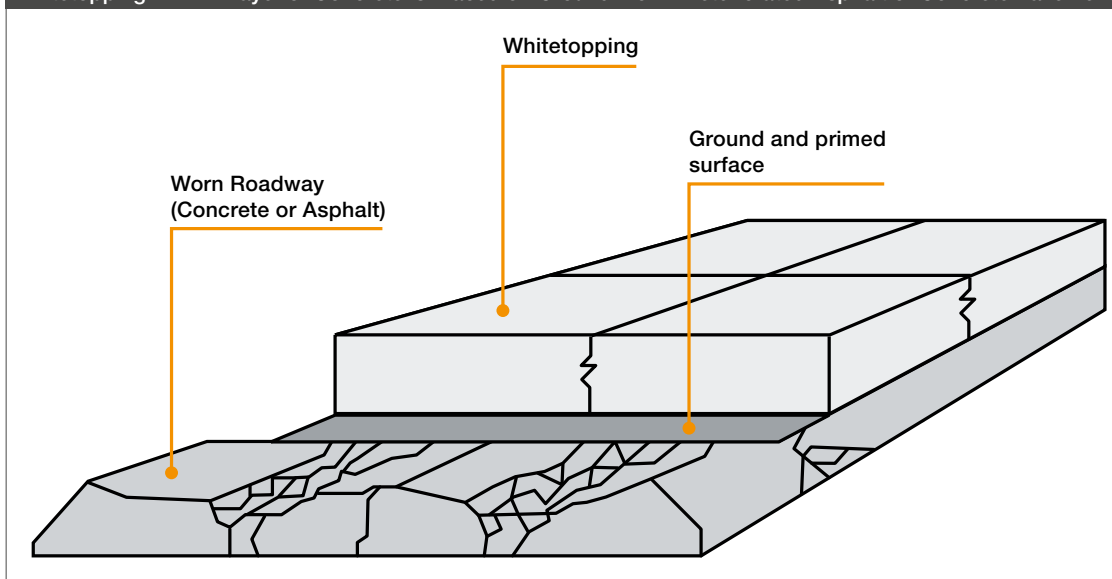
A Visible Success

For comparison, an adjacent test section was repaired with concrete that had not been modified with polymer. After one-and-a-half years, an initial inspection already revealed significant differences: The polymer-modified concrete road surface exhibited visibly less wear than the unmodified reference area.



Rather than completely renewing the road, workers merely ground down the damaged layer and installed a new top layer, with the existing road serving as the base course.

Whitetopping: A Thin Layer of Concrete is Placed on Ground-Down Deteriorated Asphalt or Concrete Pavement



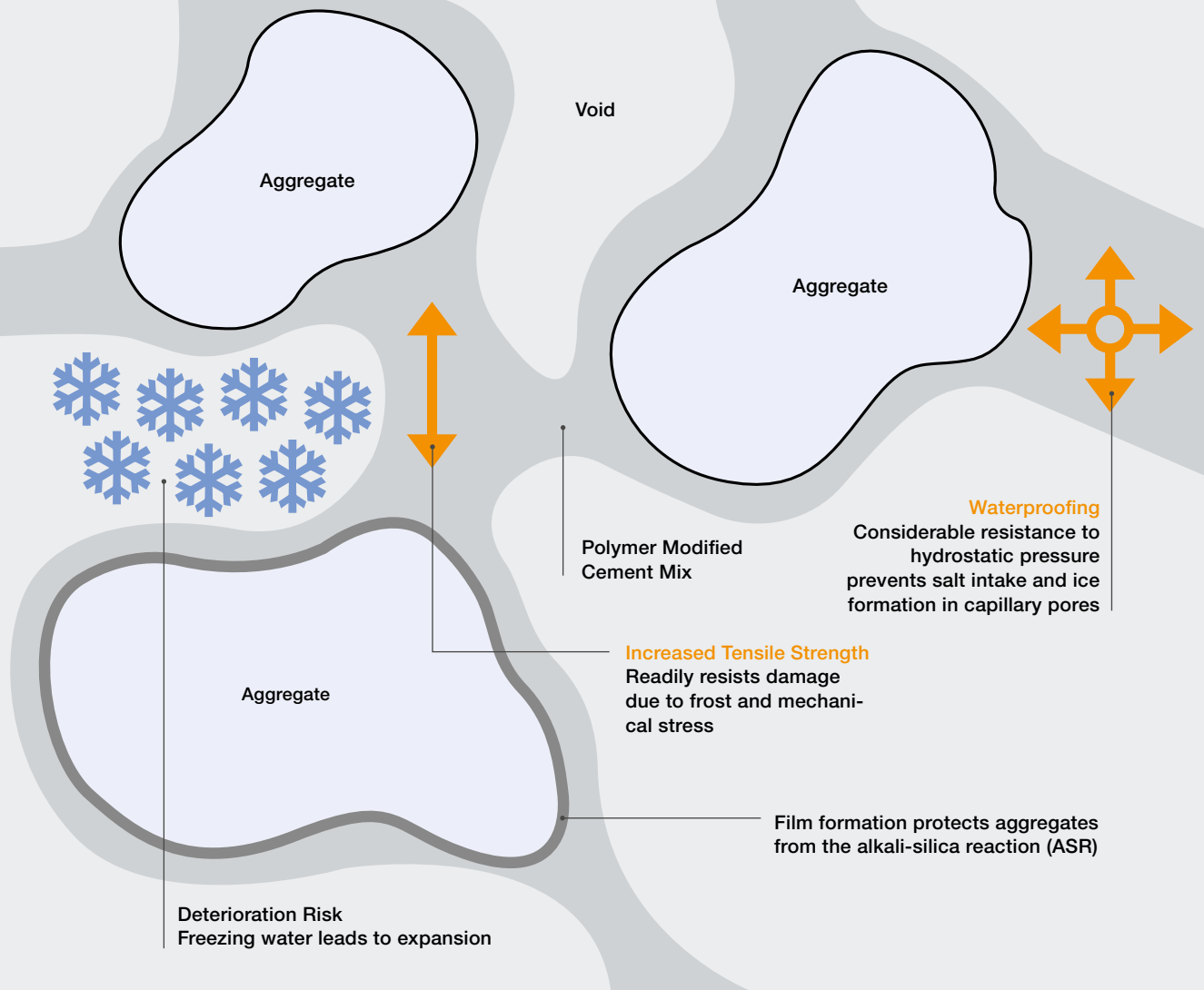
As a drop test clearly shows, concrete modified with ETONIS® reliably keeps water at bay.



ETONIS® 7000 A SPECIALTY INFRASTRUCTURE APPLICATIONS

A concrete roadway that allows thousands of liters of water to drain away in just a few minutes? Roads that reduce tire noise? Pervious concrete based on ETONIS® 7000 A does both.

Basic Effects of ETONIS® on Pervious Concrete



A New Generation of Pervious Concrete

While porous concrete has been used in the US since the 1970s, the material was no match for the heavy traffic on German roads or for the requirements of many freeze-thaw cycles. WACKER has worked with prominent concrete manufacturers to develop a new generation of pervious concrete that can withstand heavy mechanical stress and does an excellent job of resisting freezing temperatures and road salt.

Protection from Flooding

Heavy rains pose a risk for densely populated urban areas – one solution is pervious concrete. As part of the country's Sponge City Initiative, 30 cities in China have so far constructed roadways made of modified pervious concrete. The goal goes beyond merely preventing floods – the initiative is also intended to improve the water supply by recapturing a portion of the water.

An Effective Sound Absorber

Pervious concrete can reduce noise from moving vehicles by some 5 dB(A) or more. For the human ear, this is equivalent to a 50% reduction in noise. Unlike porous asphalt, pervious concrete retains its sound-absorbing properties even when external temperatures are high.

Advantages of ETONIS® 7000 A ...

... in fresh concrete

- Because the cement paste adheres better to aggregate stones, it sticks on the aggregates in response to compression and does not plug pores in no-fines concrete.

... in hardened concrete

- Reduced modulus of elasticity
- Significantly higher flexural and tensile strength
- Highly resistant to freezing and road salt
- Significantly reduced susceptibility to cracking

RAILWAY TUNNEL, GERMANY

PAVING THE WAY TO SAFETY

Thanks to porous concrete, the Babenroth Tunnel near Göttingen has been accessible to vehicles for fire and emergency medical personnel for several years.

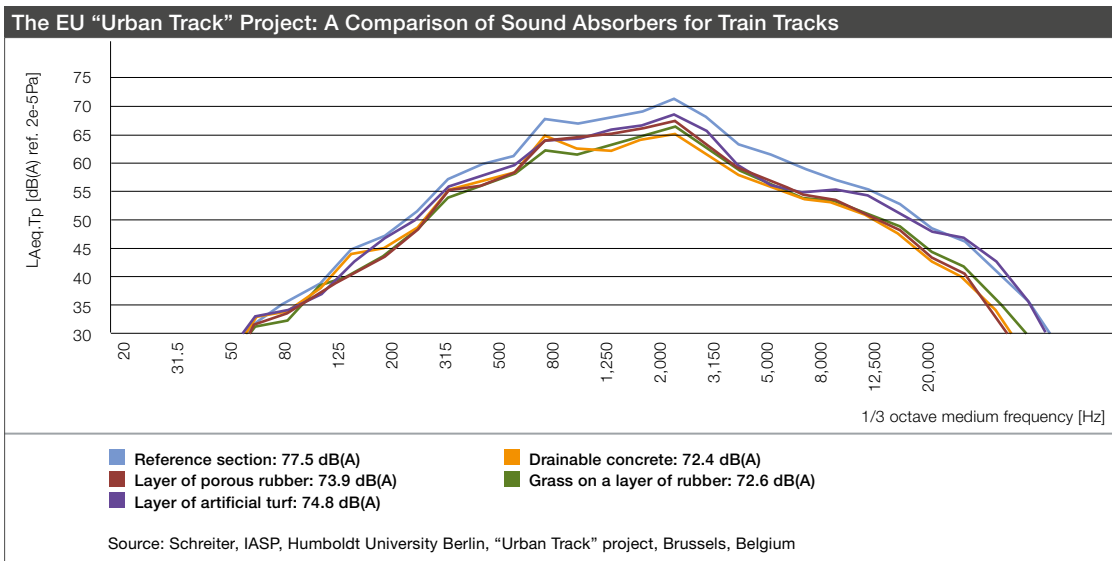
According to an European safety regulation, railway tunnels must be easily accessible for rescue vehicles and fire trucks. Deutsche Bahn, Germany's national rail company, must therefore renovate many tunnels. To retrofit the one-kilometer-long Babenroth Tunnel, the company used a porous concrete based on ETONIS®.

A Paved Road in the Tunnel

A surface of even, seamless, pervious concrete 16 cm thick has been in place alongside and between the tracks since 2013. These sections of concrete allow rescue vehicles to drive quickly through the tunnel in an emergency. While water cannot penetrate the surface of normal concrete, the surface of pervious concrete is permeable, preventing standing water from forming in the tunnel.

The Mix Makes all the Difference

Pervious concrete is made with aggregate stones that measure five to eight millimeters across, making them all roughly the same size. Because these gap-graded stones, as they are called, cannot be packed together tightly, cavities arise naturally. In contrast dense concrete is made with stones that vary in size, usually from 0.5 to 32 millimeters in diameter, with the smaller stones filling the gaps between the larger ones.



WACKER and HeidelbergCement already tested this particular application successfully back in 2010. As part of the EU's "Urban Track" research project, drainable concrete was laid between streetcar tracks. The outcome showed that the porous road surface absorbed more than 5 dB(A).





“It took collaboration with WACKER to create a polymer binder that critically improves the mechanical properties of pervious concrete.”

Siegfried Riffel,
HeidelbergCement

SPONGE CITIES IN CHINA

DESIGNED TO PREVENT FLOODING

Heavy rains and pavement have been causing more and more catastrophic flooding in China. At the same time, these very same metropolitan areas often suffer from water shortages and excessive heat in the summer. To combat these problems, the government launched the Sponge City program in 2015. The first projects are already underway – and ETONIS® is playing an important role.

Effective Stormwater Management

Thirty Chinese cities have since joined the Sponge City initiative, which focuses on making streets and plazas permeable to water. Pervious concrete captures precipitation across large areas, which secures the cities' water supplies. Creating parks and wetland areas to absorb stormwater is another prong of the initiative.

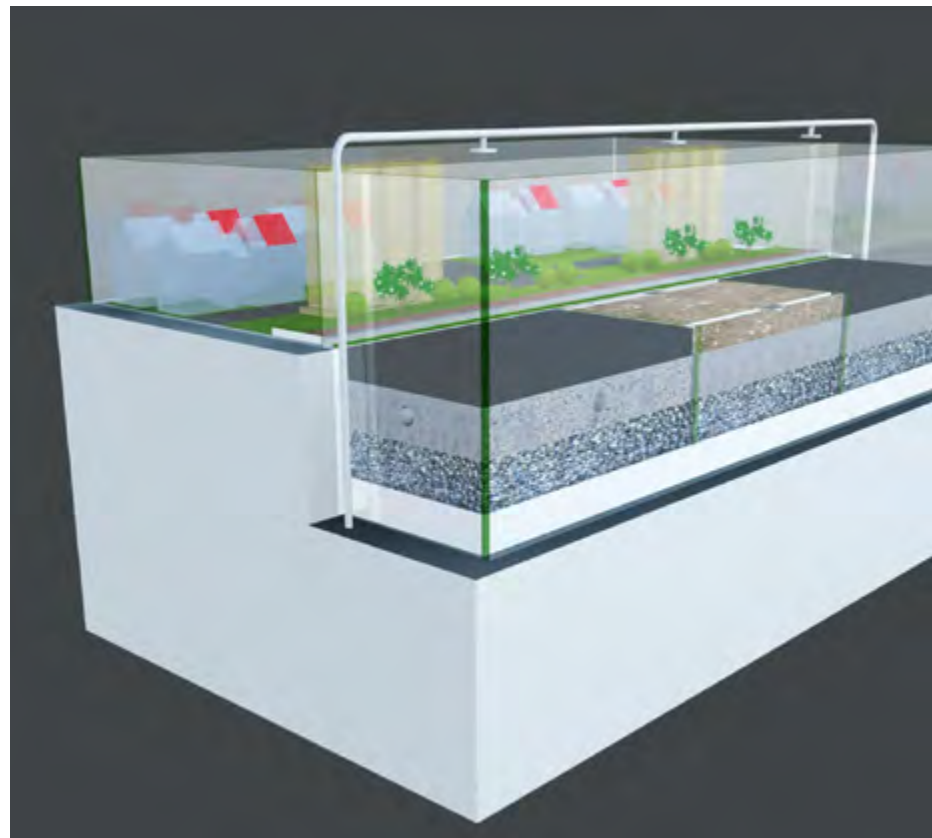
Reducing the Heat Island Effect

More green within the city has yet another advantage: paved surfaces cause metropolitan areas to heat up dramatically. Parks and green roofs, by contrast, absorb solar energy. In addition, when water absorbed by the green surface evaporates, it cools the surrounding area as well.

Modified porous concrete plays an important role in this cycle. In combination with drainage systems, it allows municipalities to capture stormwater and store it in retention basins. And because of its cavities, porous concrete only holds a modest amount of heat, which likewise mitigates the heat island effect.



Shanghai, Minhang Country Park, light load road surface.



Sponge City Model



Numerous Sponge City Reference Projects

The first permeable surfaces based on concrete modified with ETONIS® have since been completed, including two projects in Shanghai. At the new Minhang Country Park, 20,000 square meters of roads and paths have been built with an open-pored design. At Jiading Country Park, cars drive on roads made of modified porous concrete. And even at the new, high-tech development zone in Chengdu – the Tianfu New Area – pedestrians are happy to have dry pervious concrete paths, even when it pours.

THE SILBERBACH REST AREA, GERMANY READY FOR HEAVY TRUCK TRAFFIC

Trucks from all over Europe roll across the parking lot of the Silberbach freeway rest area every single day. And the lot has been putting polymer-modified pervious concrete based on ETONIS® to the test since 2016.



After two years of weather influences and maneuvering from trucks the concrete layer is still in excellent condition.

The A6 (500 km) is one of Europe's important east-west freeways, running through southern Germany from the Czech to the French borders. Visitor traffic at the Silberbach rest area in Bavaria is correspondingly heavy. For WACKER and one of its industrial partners, this has provided the ideal setup for testing a polymer-modified, pervious concrete under real-world conditions. To this end, the partners installed a 1,600 m² layer of pervious concrete on the rest stop parking lot in 2016. Their long-term observations revolve around the behavior of the porous concrete with respect to the considerable brake load and maneuver from trucks.

CDF test: Resistance to frost and road salts is tested by subjecting cubes to freeze-thaw cycles with deicing media and then measuring how much mass they lose.



Without ETONIS®: >2,500g/m²
(destroyed after 12 cycles)



With ETONIS®: 880g/m²
(28 cycles passed)

FIELD TESTING IN THE US

ETONIS® PREVAILS

Which new pervious concrete blend withstands road salt the best? That was the key question for researchers from Middle Tennessee State University and the Tennessee Concrete Association.



Researchers install the modified pervious concrete

Whereas plenty is known about the long-term behavior of traditional concrete under freezing conditions, we have little equivalent data on the latest generation of porous concrete. Middle Tennessee State University in the US set about closing that gap.

Comparative Field Studies

In the winter of 2016, the scientists collaborated on a research project with the Tennessee Concrete Association to determine which blend of pervious concrete was best able to resist freezing conditions and road salt. To this end, they tested a number of different formulations on a large parking lot. Their findings? Of all of the blends they used, concrete modified with ETONIS® withstood the most freeze-thaw cycles.

From those results, the researchers deduced that pervious concrete surfaces formulated with ETONIS® would be long-lasting and thus economical.

ETONIS® 9000 M

STRUCTURAL MATERIAL

On the one hand, composite materials made of concrete need to be extremely strong and long-lasting. On the other hand, they must also be lightweight, elastic and easy to process. ETONIS® allows you to meet all of these different demands.

A Reliable Composite for Textile- and Fiber-Reinforced Concrete

Steel-reinforced concrete is very heavy. Thin elements, such as building exteriors require lightweight materials. For applications such as these, builders have increasingly turned to reinforcements made from glass-fiber mats, plastic fibers and, most recently, carbon fibers. That reduces the weight of the composite while, at the same time, increasing its flexibility – and that, in turn, makes it less susceptible to cracking. Another advantage of fiber- and

textile-reinforced concrete is that it is not vulnerable to corrosion. A concrete admixture will also allow you to improve the bond between the concrete and the fibers: Studies on polypropylene fibers have shown, that the tensile strength of the composite material can be increased by up to 25%, through the addition of ETONIS®. WACKER concrete admixtures make it possible to create entirely new composites as well. It was thanks to ETONIS®, for example, that the Roca Gallery in London, was able to construct the spectacular flowing lines of its thin-walled exterior elements, which are based on an aluminum core.



Dense and stable: Self-filling concrete fills in the gaps between the stones in the bottom half of this example.

Efficient Renovation Right at the Construction Site

Thanks to WACKER's self-filling concrete compound, you now have an efficient technology for renovating concrete structures at your disposal. Polymer-modified concrete allows to prepare the composite material right at the construction site, by taking materials already available on site (such as rough stone) and pouring a highly flowable cement slurry modified with ETONIS®, over them, forming a strong bond.

Advantages of ETONIS® 9000 M ...

... in fresh concrete

- Excellent adhesion to smooth metal and wet surfaces
- Deformation and flow properties (rheology) can be controlled effectively.

... in hardened concrete

- Low modulus of elasticity results in considerable ductility and flexural strength.



Innovative polymer-modified, fiber-reinforced concrete exhibits ductile behavior under tensile stress, making it increasingly popular among builders.

FIBER-COMPOSITE COMPONENTS DOING WHAT OTHERS CAN'T

How do you construct a building whose form resembles flowing water? How do you stabilize concrete without steel reinforcement? The answer lies in concrete formulated with ETONIS®.

Zaha Hadid was an architect famous for creating designs that pose unprecedented challenges for engineers. For the Roca Gallery in London, the challenge was the extreme flowing profiles of the architectural concrete elements.

Novel Composites

A number of builders turned down the job point-blank, but one company from Bavaria was up to the challenge. In order to keep the concrete elements as lightweight as possible, the experts at this precast concrete company developed a composite with an aluminum honeycomb core. One of the key elements was ETONIS®, an additive that allowed the concrete to be modified so that it would adhere well to aluminum, while exhibiting a high level of ductility and the necessary flexural strength. The considerable plastic deformability of the material keeps cracks from forming in the thin-walled concrete elements.

The Roca Gallery in London. For nearly two years, engineers fine-tuned the organic contours of the concrete composite elements. ETONIS® was essential to the design.



SELF-FILLING CONCRETE COMPOUND PUTTING EFFICIENCY FIRST

A new technology for any construction projects that have to move along quickly: Self-filling concrete compound (SFCC) concept from WACKER.

Self-filling concrete compound, or SFCC, is a new concrete technology from WACKER that, unlike traditional concrete – which is delivered to the construction site as a premade, pumpable mixture – can be prepared right on site. To do that, builders stir water into the modified dry-mix mortar and pour it over the existing stone – an exceptionally strong concrete composite forms very quickly.

A Compound for Every Situation

The advantages of the new method are obvious: The compound is there where you need it, when you need it – a just-in-time solution without a long wait. SFCC is impressive from a technological point of view as well. This highly fluid mixture creeps into every last crack, reliably filling in the gaps between stones. The strong bond that forms minimizes susceptibility to cracking. Setting time and strength can be adjusted to the local climate and to the time frame of the project at hand.

A Diverse Range of Applications

In South Korea, SFCC was used for upgrading a rail line to accommodate high-speed trains. In order to achieve the necessary level of stability, the gravel rail bed had to be replaced with a fixed, concrete surface – a complex undertaking. Thanks to SFCC the line could be reinforced right on site.

And in Brazil, SFCC made it possible to renovate a shopping center in just a few days. Breaking up the worn concrete walkways and pouring SFCC over the crushed stone allowed developers to avoid the costly process of replacing these surfaces in their entirety.



THE BURGHAUSEN ALZ CANAL, GERMANY

STABILITY CAST FROM A SINGLE MOLD

The Alz Canal has been supplying electricity and cooling water to our Burghausen site since 1922. The canal underwent its first complete restoration in 2016, and self-filling concrete was used to refurbish complicated spots.

After nearly a century of operation, the Alz Canal was showing signs of aging. It was time to completely overhaul the 16 km concrete bed, the tunnels and the associated structures.

A Fast Solution for Difficult Spots

In 2016, we tested self-filling concrete compound – a product developed in house and referred to as SFCC for short – in a relatively small area. This was the first time that SFCC had been tested under realistic conditions, and the goal was to repair an area next to some steps where the concrete was crumbling. The first step in the process was to remove the loose stone (see photo, top right) and to fill the area to be repaired with gravel. The self-filling concrete was then poured over the loose stone and a short time later, the form was removed to reveal a smooth, solid concrete surface (see photo, bottom right). Depending on the formulation, SFCC will set in less than one hour.





The self filling concrete is applied.

Flow Characteristics are Key

The flow characteristics of SFCC are an important factor in the success of projects like these. The liquid mixture must not flow too slowly or too quickly through the rock structure. If it stops flowing too soon or if air bubbles form, the stability of the entire concrete component will be at risk. Adding ETONIS® results in a highly unique rheology that cannot be achieved with conventional superplasticizers.

Water has since resumed flowing over the concrete in the Alz Canal and is putting the performance of SFCC to the test. The odds are good that the compound will remain stable until the next time the canal undergoes a general renovation.



Before: Large-scale spalling made the canal in urgent need of renovation.

After: A smooth, crack-free surface. The repair was made using self-filling concrete including ETONIS®.

POLYMERS FOR THE FUTURE: 3D-PRINTED CONCRETE BUILDINGS

WACKER ranks among the pioneers of polymer chemistry. For decades, our scientists have focused on innovative additives for the construction industry.

Our technical centers throughout the world continuously develop new applications and products based on findings from our Corporate R&D in Germany. This means that your concrete will have exactly the properties you need.

Collaboration with Research Institutes

Knowledge is the only resource that grows when you share it. That's why we cooperate with prominent concrete manufacturers, research institutes and universities – because doing so, means we can respond to new trends more quickly and accelerate the journey from lab to market.

An Up-And-Coming Field: Houses from a 3D Printer

The construction industry is pinning a lot of hopes on 3D printing with concrete. Sophisticated geometric shapes that architects could once only dream of, may one day be generated at the touch of a button – and the cost would likely be well below that of buildings constructed using conventional techniques.

Even though, the first 3D-printed model houses are already available to tour, a fair bit of application research still needs to be done before full-scale production can become a reality. Studies are currently underway at WACKER to determine the optimum products for concrete blends for 3D printing. Factors under consideration include the effect of polymeric binder on the structural consistency and durability. Such as flexural and tensile strength, freeze/thaw stability and thus, crack reduction. Likewise under investigation are rheology modifiers in regards of flow and workability properties of the printed concrete.





The concrete of the future will be subject to many demands: It will need to make economical use of resources, resist fatigue, and enable innovative load-bearing structures. Our aim with ETONIS® is to make a decisive contribution toward that development.

Concrete construction is more innovative than ever before. Whether in porous concrete, fiber-reinforced concrete or our self-filling concrete compound, ETONIS® additives are always part of the solution.



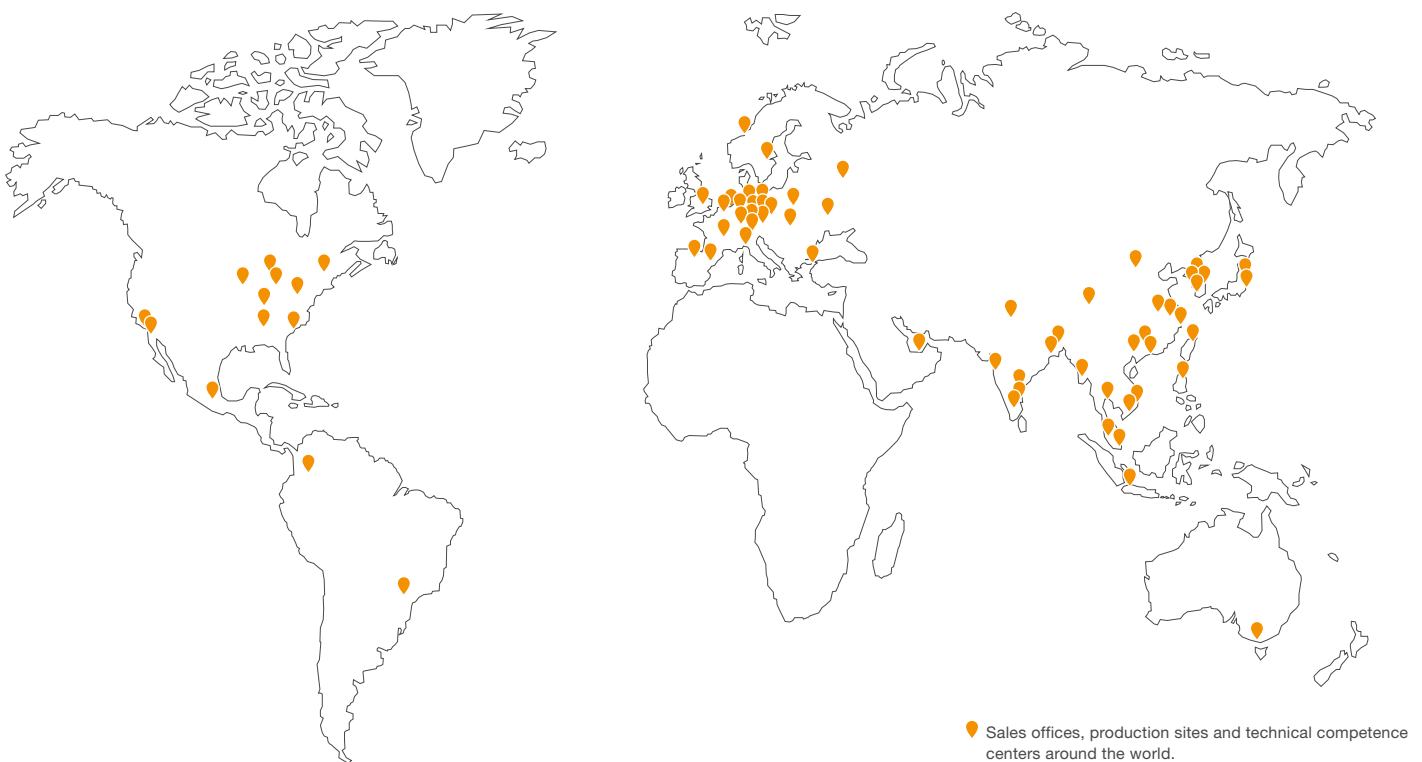
Contact us

If you're looking for novel modifiers, or for a partner for your forward-looking application, feel free to let us know:

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EXPERTISE AND SERVICE NETWORK ON FIVE CONTINENTS



WACKER is one of the world's leading and most research-intensive chemical companies, with total sales of €6.21bn. Products range from silicones, binders and polymer additives for diverse industrial sectors to bioengineered pharmaceutical actives and hyperpure silicon for semiconductor and solar applications. As a technology leader focusing on sustainability, WACKER promotes products and ideas that offer a high value-added potential to ensure that current and future generations enjoy a better quality of life, based on energy efficiency and protection of the climate and environment.

Spanning the globe with 4 business divisions, we offer our customers highly-specialized products and comprehensive service via 26 production sites, 23 technical competence centers, 14 WACKER ACADEMY training centers and 52 sales offices in Europe, North and South America, and Asia – including a presence in China. With a workforce of some 14,400, we see ourselves as a reliable innovation partner that develops trailblazing solutions for, and in collaboration with, our customers. We also help them boost their own success. Our technical competence centers employ local specialists, who assist

customers worldwide in the development of products tailored to regional demands, supporting them during every stage of their complex production processes, if required. WACKER e-solutions are online services provided via our customer portal and as integrated process solutions. Our customers and business partners thus benefit from reliable service and comprehensive information to enable projects and orders to be handled fast, reliably and highly efficiently. Visit us anywhere, anytime around the world at: www.wacker.com



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