

# FEATURES

Number 3, April 2009

## **Polymeric Binders for Tunnel Walls – New Standards in Infrastructure Projects**

**Whether in tunneling, mining, hydraulic engineering or road construction, sprayed concrete is a construction material of major importance. The demands made on the concrete are high: it must provide the necessary strength, stability and impermeability. For WACKER application engineers in Burghausen this was not enough. They wanted to reduce rebound during spraying while also making the sprayed concrete water resistant. They developed polymeric additives for sprayed concrete for tunnel construction, making a major contribution toward building a new tunnel for the Stetten salt mine.**

**Germany's oldest salt mine ...**

The subterranean world of the Stetten salt mine is white and covers an area greater than ten square kilometers – the size of Italy's Isle of Capri. The Stetten salt mine is one of the oldest and yet most modern salt mines in Germany. It was built back in 1852 at the suggestion of Prussia's king Frederick William IV. "Initially, the mine produced table salt, then industrial salt. Today, the Stetten salt mine produces some 500,000 metric tons of industrial and road salt annually," says mine director Alfred Höllerbauer, summarizing the mine's 150-year history.

**... is part of the WACKER-world**

But the mine has more to offer than just road salt: "A large portion of the rock salt is shipped to WACKER's Burghausen plant for producing silicones, hyperpure silicon, organic intermediates and pyrogenic silica. And to ensure the site stays economically viable, we supplement our mining activities by backfill-

**A new tunnel: The Clara-tunnel**

ing the worked out tunnels with mineral refuse,” continues Höllerbauer. For this to be done efficiently and safely, however, an additional tunnel into the mine was needed, the Clara tunnel, which has connected the salt mine with the surface since August 12, 2008.

**WACKER is testing new formulations ...**

Let’s look back at summer 2008: WACKER engineers at the Burghausen construction-applications lab were developing and testing polymeric dispersions and dispersible polymer powders in new applications. As tunneling and mining are interesting fields, the researchers tried out a novel WACKER product in the new Stetten tunnel: polymer-modified sprayed concrete.

**... to stabilize tunnel walls**

This concrete stabilizes tunnel walls. Very soon after blasting, tunnel builders spray it onto the exposed rock. “One problem here was that we had to penetrate the impermeable layers above and below the rock – and there, of course, we came across ground-water,” explains Höllerbauer. “Fresh concrete is very fragile and wouldn’t stick to wet walls.”

**Premiere for the polymer-enhanced sprayed concrete**

WACKER application engineers had already been in the tunnel to try out the new polymer-enhanced sprayed concrete on a small area of tunnel wall. Though only because it was a good opportunity to try out the new product under realistic conditions in WACKER’s own tunnel. “However, the tests showed the new polymer-enhanced sprayed concrete to be so promising that it could be the ideal solution to impregnate our tunnel,” recalls Höllerbauer, as WACKER experts are drilling small holes in the new tunnel wall in order to take samples back to Burghausen.

“We sprayed 40 meters of tunnel with this concrete,” recalls

**ETONIS-modified concrete hardens fast ...**

construction manager Christian Schönlechner of Jäger Bau GmbH, the company commissioned to build the tunnel.

“ETONIS-modified sprayed concrete is a little thicker and stickier than the concrete we usually use. One advantage is that we need less accelerator to make the concrete set and harden.”

**... and reduces rebound**

The wetter the concrete is, the more accelerator it must contain. However, concrete only tolerates a limited amount of this additive. If the complex formulation contains too much accelerator, the concrete gets too hot and doesn't bind to form the desired hard, impervious layer. Schönlechner stresses another advantage of the novel material: “ETONIS-modified sprayed concrete is softer, and there is significantly less rebound – far less of the concrete we sprayed fell off the wall.”

**Better concrete formulation thanks to years of research**

The core samples taken from the tunnel are carefully analyzed in Burghausen. “The concrete we used in the Stetten tunnel is based on normal sprayed concrete,” explains Klaus Bonin, head of a WACKER applications lab in Burghausen. “The only difference is that we used better quality ingredients because we wanted the best possible concrete for the conditions in the tunnel,” he continues. It was thanks to the many years of research that this new concrete additive was so easy to use. WACKER specialists have been working on these formulations for four years. Originally, this work was only intended to reduce rebound when concrete is sprayed onto tunnel walls. “What is a construction material one moment is just wasted rebound only seconds later, and that is very annoying and costly,” says Bonin. “Because the polymer is sticky, we hoped to significantly reduce the rebound.” The Stetten tests confirmed what construction engi-

**Less waste ...****... and lower costs**

**Damp walls – no problem**

neer Schönlechner had observed in practice: only half as much ETONIS-modified concrete ended up as rebound on the tunnel floor. It came as a pleasant side effect that the enhanced sprayed concrete also adhered better to wet walls and provided a superior shield against wetness in the tunnel.

**Core samples allow a better understanding**

Tests performed while the novel material was under development likewise showed ETONIS-modified concrete to be a powerful problem solver in tunnel construction. “I use core samples to measure the concrete’s increase in strength over time,” says Bonin, as he clamps a flashlight-sized concrete cylinder from Stetten in a large press. “Pressure is exerted on the cores until the material yields and the first cracks appear,” he explains before starting the press. This is what happens in the tunnel, too, when the tunnel tubes exert pressure on the new concrete. “In six months’ time we’ll take new core samples, and then we’ll be able to comment on the improvement of the concrete’s long-term stability.”

**ETONIS – a promising solution for infrastructure projects**

The WACKER specialists in Burghausen are well able to confirm one thing already: with its waterproofing properties and reduced rebound, the polymer-modified sprayed concrete is a promising and cost-cutting solution for many tunneling projects.

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**Background Information on the Stetten Salt Mine**

- The Stetten salt mine is one of the oldest and yet most modern salt mines in Germany. In 1852, the Stetten salt mine (near Haigerloch, Germany) was built at the suggestion of Prussia's king Frederick William IV. Mining of rock salt began as early as 1854, initially focusing on table and animal-feed salt. Following World War I, the mine became the property of "Preussische Bergwerks- und Hütten-AG," today's Preussag. In 1924, WACKER leased the mine to cover its rising rock salt needs, eventually buying it in 1960.
- Today, the Stetten salt mine produces some 500,000 metric tons of industrial and road salt annually. A large portion of the rock salt is shipped to the Burghausen plant for producing silicones, hyperpure silicon, organic intermediates and pyrogenic silica.



Spraying polymer-enhanced concrete onto a tunnel wall in the Stetten salt mine. The sprayed concrete stabilizes the tunnel and keeps out water. The innovative formulation also reduces rebound during spraying, thus minimizing wastage and material consumption (photo: Wacker Chemie AG).

Analyzing tunnel core samples in the Burghausen applications lab to determine the sprayed concrete's waterproofing properties and its strength increase over time (photo: Wacker Chemie AG).



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Note:

*These photos are available for download at*  
<http://www.wacker.com/presseinformationen>

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**The company in brief:**

WACKER is a globally active chemical company with some 15,900 employees and annual sales of around €4.3 billion (2008).  
WACKER has 27 production sites and over 100 sales offices worldwide.

**WACKER SILICONES**

Silicone fluids, emulsions, rubber and resins; silanes; pyrogenic silicas; thermoplastic silicone elastomers

**WACKER POLYMERS**

Polyvinyl acetate and vinyl acetate copolymers in the form of dispersible polymer powders, dispersions and solid resins used as binders for construction chemicals, coatings, adhesives, paints, plasters and nonwovens

**WACKER FINE CHEMICALS**

Fine chemicals, biologics and other biotech products such as cyclodextrins and cysteine

**WACKER POLYSILICON**

Polysilicon for the semiconductor and photovoltaics industries; solar wafers

**Siltronic**

Hyperpure silicon wafers and monocrystals for semiconductor devices