Interview
From Idea to International Reference – RASCOR's Hybrid Technology

The leading trade journal Geotechnik in conversation with Norbu Liebetrau about RASCOhybrid HMS317, the interplay between research and practice, the importance of the bypass system, and the key innovation of the CCP plant.

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Mr. Liebetrau, you are one of the co-developers of the combined polyurethane-cement suspension. Can you give our readers a brief outline of the development path from the beginnings to today?
The idea of combining polyurethane with cement has been under discussion for many years. Already before the 2000s there were corresponding considerations, and simplified versions were even implemented. However, these versions were not really effective or lacked the necessary technical prerequisites. Ultimately, these versions and ideas were only pursued to a limited extent.

In 2017, we took up the subject again as part of an interdisciplinary working group. The goal was to finally combine the advantages of both material worlds once and for all: the reactivity and penetration ability of polyurethane with the volume stability and cost-effectiveness of cement.

And then there were first successful tests, correct?
Exactly, and the system was technically further developed in 2018. The focus was particularly on adapting the polyurethane components and developing a suitable bypass mixing system that enabled homogeneous and controlled mixing. Subsequently, the findings were discussed with colleagues – which led to the idea of using the system specifically in the Semmering Base Tunnel. It was there that the potential of hybrid technology was impressively demonstrated.

And how did things progress after that?
Hardly a year later, in 2019, the first pilot applications followed on construction sites – a decisive step to test and further optimize the system. From 2020 onwards, we were able to deliver it as a defined system solution. Since 2022, it has been used not only in the Semmering Base Tunnel but also in other demanding projects such as on Helgoland and in the Brenner Base Tunnel.

Today, RASCOhybrid HMS317 is an internationally proven system for situations in which conventional injection methods reach their limits – for example with high inflow rates, saline or pressurized water – in short: wherever a volume-stable and reactive solution is required.

How did the polyurethane solution ultimately come about?
This question touches on the relationship between laboratory and practice. The initiative clearly came from construction site practice. In strongly water-bearing areas, material loss with pure cement suspensions is often too high. At the same time, the use of pure polyurethane for large-scale applications is too expensive from the client's point of view.

And precisely because of such dilemmas, the first experiments started in the laboratory: We initially tested various types of injection materials by mixing them with cement suspensions to see what reactions occurred and whether the mixture was usable or injectable. Important factors were heat development and mixability. The right system type turned out to bepolyurethane. We discovered that the exothermic reaction of PU triggers rapid early strength while at the same time thickening the suspension as desired. This reduces water loss and significantly increases stability in water-bearing ground. Later, on site, we developed a methodology for continuously and proportionally introducing polyurethane into a cement matrix.

You were the first to use this application. How did the market react at that time, and what does it look like today compared to competitors with other solutions?
Initially, a lot of explanatory work was required. The combination of two such different material worlds was particularly in need of explanation with regard to machine and process safety. Especially planners and clients were initially rather skeptical towards a new system, since – as always – a new system first needs references. My point, however, was always: it is not a new product, but an additional support measure for cement suspensions and should always be considered as such.

But that looks different today, doesn't it?
Absolutely! Today, after successful projects in tunnelling and other complex fields, we are seeing significantly increasing acceptance – not least due to these reliable references, which are also presented at various conferences. Our references include examples of applications with sealing under extreme inflows, projects with mountain water pressures of over 70 bar, and applications in saline water.

In addition, we are now working as three specialized companies in close cooperation on a fully automated injection system. The compact CCP plant is the result of a joint development process in which Häny, as a system developer for automated injection plants, RASCOR with its many years of PU expertise, and WIWA as a specialist for PU pump technology, each contributed their strengths.

The result is an integrated system that makes hybrid injection technologies usable under demanding conditions in a safe, precise, and reproducible way – far beyond the function of a single machine. Together, the three companies combine system competence and material expertise for safe, high-precision solutions in every construction sector.

In an interview in Geomechanics and Tunneling 17/2024 (No. 3, p. 239), you mentioned that component mixing had long been a challenge. Would you say that things really gained momentum with RASCOR's development of the mixing tube in 2018? And could you elaborate a little on the advantages of this mixing tube?
Yes, absolutely! The decisive breakthrough came with the development of the bypass mixing system in 2018. For the first time, it enabled reproducible and inline homogenization of PU and cement.

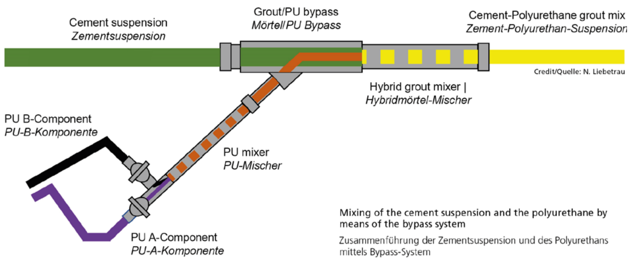

Image1: Combination of cement suspension and polyurethane using the bypass system

Another important aspect was the ability to continuously adjust the PU dosage during the injection process – for example, to control reaction time, viscosity, or penetration behavior. This made the application extremely flexible and ensured safe processing even under varying ground conditions.

In addition, this technology paved the way for automated process control – as it was later realized in the CCP plant.

You describe RASCOR as a specialist for market niches. For a globally active company, there seem to be quite a few of those, correct?
Not exclusively, of course, but it is true: our strength lies precisely in such niches that are technically highly demanding and often come with challenging boundary conditions – everywhere standard solutions do not work.

This includes geologically difficult conditions, rehabilitation projects, hydraulically active fissures, or work under high water pressure.

Exactly in such situations, RASCOhybrid HMS317, as a hybrid system, offers superior performance – technically, economically, and logistically.

And such niches can be found …
(nods) … worldwide, yes – in the DACH region, but also in Asia, the Middle East, and the Americas. Interestingly, we are seeing that these so-called niches are hardly niches anymore, but increasingly being recognized as strategically important specialty markets.

You often like to emphasize the concept of harmony between materials. Could you elaborate on that?
With pleasure! By harmony I mean that materials do not hinder each other, but rather complement each other functionally. In our case, the cement takes on the role of the volume-stable carrier, and the PU specifically controls reactivity and viscosity – perfect harmony! (smiles)

During the hydration phase of the cement, the PU integrates itself into the developing structure. And here we are back in the laboratory … because we were able to verify this micro-integration microscopically as well. The result is a homogeneous, finely interlocked matrix. This has the advantage of being significantly more resistant to washout and providing higher early strength.

One could describe the polyurethane as an inner framework that gives the cement stone additional stability. And it is precisely this interaction between the inorganic and organic components that makes the system unique.

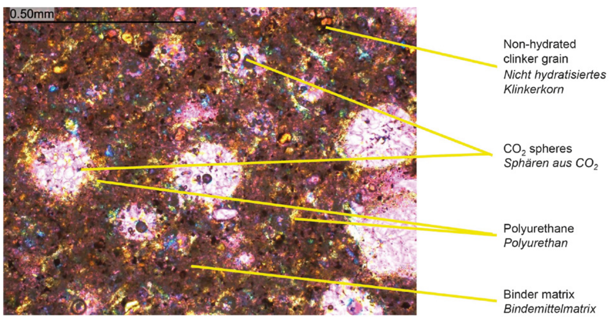

Image 2: Microscopic view of a combined cement–polyurethane suspension

Regarding the role of material properties: you say that polyurethane harmonizes with many cements; however, there are also projects where the use of more unusual cements makes an initial trial advisable. How do you proceed in such exceptional cases?
In such cases, we recommend project-specific field trials with the local cements. It is important that the cement is not only chemically compatible but also rheologically – that is, in terms of its flow behavior.

If a cement turns out to be critical, which is rather rare, we either adjust the PU dosage or propose an alternative type of cement. The decisive factor is that the suspension remains stable, homogeneous, and pumpable – especially under water-bearing conditions.

But in most cases, we find a solution even before the first borehole is drilled. Only through such early coordination can unnecessary costs and delays be avoided.

Image 3: 30 m hose test with RASCOhybrid HMS317

Polyurethane is clearly more expensive than the various types of cement. Why is it nevertheless not costly?
Quite simply because it is significantly more efficient in application. The reaction time can be accelerated and/or the viscosity increased. In situations where a pure cement suspension would simply flow away, the addition of polyurethane quickly and immediately creates a stable and solid suspension.

So it saves material …
… and above all time and effort for re-injections. In q/p tests according to Lombardi, which we carried out in our working group, it was shown that PU-cement mixtures exhibit up to 90% less washout than pure cement suspensions. A similar effect could only be achieved by adding suspension additives to the cement-water mix. The clear disadvantage of that method, however, is that the injection material has to be pressed with the fixed properties set during mixing and can no longer be adjusted afterwards.

In contrast, when the combined polyurethane-cement suspension system is used, the result is: less rework, lower overall consumption – and thus, despite the higher material price for polyurethane, lower total costs.

Doesn't service life also play a significant role in a cost analysis? And how would you describe that in comparison?
Absolutely. A system that functions reliably over decades saves maintenance costs in the long run. Combined polyurethane-cement suspensions are characterized by their high

tightness, chemical stability, and mechanical interlocking – even under dynamic loads or aggressive groundwater.

You can imagine it as a high-quality cement stone in which the polyurethane is finely distributed and fully embedded. Since the PU is introduced during the hydration phase and enclosed by the cement stone, it is permanently protected against washout. The PU component thus remains stably integrated – for decades. And that is the crucial point: in the long term, the system pays off not only technically, but also economically.

Image 4: Finished cement–polyurethane mixture with RASCOhybrid HMS317

What about the disposability of polyurethane–cement suspensions?
Fully reacted mixtures such as our RASCOhybrid HMS317 are considered inert. This means there are no volatile organic components present, and no significant leaching takes place. Since the reaction of the polyurethane is initiated even before it is introduced into the cement suspension, it proceeds irreversibly and completely – already during the mixing process. As mentioned above, the PU components bind firmly into the cement matrix.

Leachate tests in accordance with DIN 19631 also show that no relevant pollutants are released. As a result, disposal is generally possible as a non-hazardous mineral construction material.

Another ecological question, which planners also like to ask: how do your products affect groundwater?
We have, of course, had the PU components as well as the entire hybrid mixture with cement suspension specifically tested for environmental compatibility. This means: no detectable migration of relevant substances into the groundwater takes place.

Because the PU reacts completely and is firmly embedded in the cement matrix, no relevant release can occur. Our ambition is clear: maximum sealing performance with minimum environmental impact.

Let's turn to the CCP plant (Combined Cement PU), which you mentioned earlier. It went into operation this year. Why do you describe it as a springboard into the bigger picture?
Because with this plant we have taken the next development step in injection technology. The CCP plant combines automated cement and PU injection in a modular, practical system. In close cooperation with Häny – the development partner for the injection system – and WIWA as a specialist in PU pump technology, we created a solution that is standardized, flexibly applicable, and designed for complex construction requirements.

So there are no comparable high-performance systems on the market yet?
There are some that digitally map cement and PU injections. However, they are mostly in-house developments, designed exclusively for internal use. The CCP, by contrast, is not an internal special product but an open, commercially available system. It can be purchased, configured for specific projects, and deployed worldwide. Moreover, the CCP combines cement and PU injection in one continuous, digitally controlled system – with infinitely adjustable mixing ratios, real-time logging, and high process reliability.

And how did this spectacular development come about?
It was created through close cooperation between RASCOR (chemical injection materials and mixing technology), Häny – Mixing and Injection Technology, and WIWA (PU pump technology). The result is a standardized yet versatile system – a real step towards industrial, automated construction injection.

What ecological benefits does such a plant provide?
The CCP plant not only optimizes the injection process technically but also brings clear ecological advantages. Precise dosing minimizes material losses and reduces re-injections – saving resources and cutting unnecessary emissions.

In addition, the compact design allows shorter transport routes, as it enables decentralized or mobile use. The energy-efficient mixing processes – especially with cement – also contribute to lowering the CO_2 footprint.

And last but not least: through real-time control and documentation, the entire injection process becomes more transparent, cleaner, and more efficient – which also significantly reduces the ecological footprint on the construction site itself.

Image 5 CCP plant (combined cement-PU)

A question for the planners among our readers: At what stage of project planning would you prefer to be involved – or is that the wrong question?
(smiles) On the contrary – it is absolutely the right question. The earlier we are involved, the greater the impact on efficiency, safety, and cost-effectiveness. In many – exemplary, from our perspective – cases, we receive inquiries years before the tender, when it comes to fundamental considerations such as ground classification, sealing strategy, or logistics.

The fact is that, especially with complex injection tasks, a well-coordinated concept at an early stage can prevent later problems – whether technical, scheduling, or economic. A well-planned injection concept saves time, money, and nerves.

That is why our clear recommendation is: involvement already at the preliminary planning stage – not only once the water starts flowing.

Perhaps a look into the future – or rather the "present future": what is your outlook on the importance of AI, for example with regard to certain geological conditions?
AI will play an increasingly important role in injection technology – above all in the analysis of geological data, the optimization of injection parameters, and the prediction of material consumption. Especially under heterogeneous ground conditions or when recipes need to be adjusted in real time, AI can provide valuable support – faster, more reliable, and with more data background than has been possible so far.

So AI as an all-round solution?
(smiles) Definitely not! The key will be to understand AI as an assistance system – embedded in an experienced team of engineers, planners, and contractors. Then it can not only accelerate our work but also improve its quality. For me, the future clearly lies in the combination of experience, technology – and intelligent support.

Are there also geological or construction conditions where you would advise against a hybrid system and a classical cement injection would be the better choice?
Yes, certainly. A hybrid system shows its advantages wherever complex conditions exist, such as strongly water-bearing layers, unstable rock formations, or high pressures. However, when dealing with simple, well-controllable conditions – for example relatively dry, homogeneous rock or well-defined, stable fissures – a classical cement injection is usually entirely sufficient.

In such cases, a combined polyurethane–cement suspension would technically be possible, but economically not sensible. The decision should always be made based on cost-effectiveness, technical requirements, and ecological framework conditions.