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Cement Lime Gypsum
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ISSUE 2
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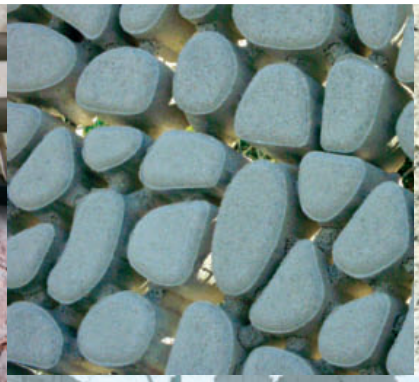
SPECIAL 2014 //
Drymix Mortar
Construction Chemistry

ZKG INTERNATIONAL

DRYMIX MORTAR
CONSTRUCTION CHEMISTRY

EIRICH



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ADVERTISER INDEX

EVENT PREVIEW

Date Place	Event Contact
30.09.–02.10.2014 Nuremberg/Germany	**POWTECH 2014** www.powtech.de
06.10.–08.10.2014 Kassel/Germany	**German Conference on the Chemistry of Construction Materials** www.gdch.de
15.10.–16.10.2014 Casablanca/Morocco	**North African Coatings Congress** www.drymix.info
11.11.–13.11.2014 Marrakech/Morocco	**19th AUCBM** www.aucbm.org
11.11.2014 Singapore	**9th Annual SEADMA Conference** www.drymix.info
25.11.–28.11.2014 Shanghai/China	**bauma China 2014** www.bauma-china.com
19.01.–24.01.2015 Munich/Germany	**BAU 2015** www.bau-muenchen.com
21.01.2015 Munich/Germany	**Casual drymix.info meeting during BAU 2015** www.drymix.info
20.04.2015 Nuremberg/Germany	**5th International Drymix Mortar Conference (idmmc five)** www.drymix.info
20.04.–25.04.2015 Paris/France	**INTERMAT 2015** http://paris.intermatconstruction.com

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Dry mortar produced according to the state of the art

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Innovative binder based on activated fly ash for products with chemical and corrosive load

Page 44
Salt resistant mortars: present knowledge and future perspectives

PE bags will become the standard

The HAVER ADAMS® technology stands for the filling of bulk powder products with difficult flow properties into air-tight PE bags. These bags are not only clean, tightly and weatherproof; their compact size also facilitates space-saving transportation and storage and also offers several advantages for your marketing!

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DEUTSCHE BAUCHEMIE

NEXT STEP platform with extended information content

NEXT STEP, the training and further education platform (www.deutsche-bauchemie.de/nextstep) set up and operated by Deutsche Bauchemie (the German Building Chemistry Association) to provide information for newcomers to the industry as well as to established professionals has now been extended. One central point of the portal is up-to-date information about study opportunities and doctorate options in the field of building chemistry. The provided information is based on a comprehensive survey of all German universities and institutes of higher education with regard to their current programme relating to this specialist field.

The list of academic institutions currently includes 18 universities and 19 institutes of higher education. Updating the portal, which includes regular checking and revising of all contact data etc., also increasingly involves the promotion of international cooperation and networking with scientific bodies. Totally in keeping with contemporary needs, NEXT STEP therefore risks a look beyond the borders of Germany and includes international institutes offering courses focussing on "Building Chemistry" in the information provided in the portal. This internationalization has included providing an English-language version of the website. At present, this contains the most important information and opportunities for interested persons from foreign countries.

International projects are also at the centre of interest of Prof. Dr.-Ing. habil. Thomas Böllinghaus. The Vice-President of the "Bundesanstalt für Materialforschung und -prüfung" (Federal Institute for Materials Research and Testing) has contributed a report under the heading "Stimmen der Bauchemie" (Voices of Building Chemistry) in which he poses the question: "Under very hot conditions in towns and cities, how can concrete paving stones cool themselves down?" – and refers to a current international project (SeCCoPa), which concerns itself with such topics.

The present range of information offered by NEXT STEP is rounded off by references to new professional literature and industry events.

Norbert Schröter, Managing Director of Deutsche Bauchemie, outlined the fundamental aims and the target groups of the information portal: "For high-school graduates, NEXT STEP aims to provide initial orientation in the decision regarding which course of studies to pursue. On the level of institutes of higher education, building chemistry is becoming increasingly attractive as an elective course module for students of architecture and construction engineering. For graduates and doctoral candidates, the platform is designed to provide encouragement and suggestions for doctorates in this subject. And active professionals in the industry find valuable information concerning further education opportunities and higher professional qualifications in the field of building chemistry and neighbouring sectors."

In 2015, the platform will again be extended by adding the heading "Prizewinners". At present, Deutsche Bauchemie is running two competitions – for the "Science Medal" (awarded for dissertations) and the "Sponsorship Award" (for diploma theses). The winners will be honoured at the annual conference of the association in Baden-Baden in June 2015.

Infos under
http://www.deutsche-bauchemie.de/wissenschaftsmedaille/

NEXTSTEP
BILDUNG. ZUKUNFT. PRAXIS.

POWTECH 2014

Powder and bulk solids processing industry meets in Nuremberg

Powder and bulk solids experts from around the world will once again converge on Nuremberg from 30.09–02.10.2014. Over 700 exhibitors from more than 25 countries make POWTECH the world's number one trade fair for processing, analysis and handling of powder and bulk solids. The event is the undisputed Mecca for numerous powder and bulk solids processing industries, including chemical and pharmaceutical producers, manufacturers of foodstuffs and animal feed, processors of glass, ceramic and other minerals as well as plant engineers. The most important information and tips for visiting the trade fair are summarised below.

Every day from 10 am to 4:30 pm, the Exhibitor Forum in Hall 4 will give industry specialists the opportunity to discuss the latest trends for processing powder and bulk solids. Highlights include the Explosion Protection Forum, a presentation series sponsored by the Ostwestfalen-Lippe University of Applied Sciences, the Innovation Award and the Solids Handling Forum.

On the opening day, the "Safe and energy-efficient handling of high-quality solids" Forum will include six presentations on the special features and

benefits of various conveying and dosing systems. The focus will be on mechanical and pneumatic conveying systems, product and process safety and energy efficiency. Requirements for cleaning, hygiene, contamination and explosion protection will be explored in-depth.

The exhibitor and product search tool offers numerous practical functions for an overview of the POWTECH 2014 programme. Simply enter keywords or categories to search for products or innovations of interest and contact exhibitors directly to make appointments. In addition, a 'wish list' of exhibitors, accessible from any device, can be stored and shared. Conveniently, the wish list is linked to the floor plan and can be printed out with location maps to help visitors navigate the venue.
www.powtech.de

MAPEI

System designs now available online

Mapei has added a new category to its website: under the heading "Systemlösungen" (system solutions) information on all the company's system designs for floors and for the waterproofing of buildings is available online.

The Mapei website focuses on providing bundled and structured information. Extension of the website to include the "Systemlösungen" heading has added a clear overview of the finely inter-coordinated system solutions using Mapei products for the installation of flooring and waterproofing. Under www.mapei.de, all the system designs for the company's different business segments (tiling, natural stone laying, textile and resilient floor coverings, parquet flooring, building materials and roofing) are now available for downloading via simple and self-explanatory menu guidance.

For every system, the corresponding product and technical information is provided, together with practical working tips and product application advice. Moreover, all the technical data sheets for the recommended system products can be downloaded together as a package.

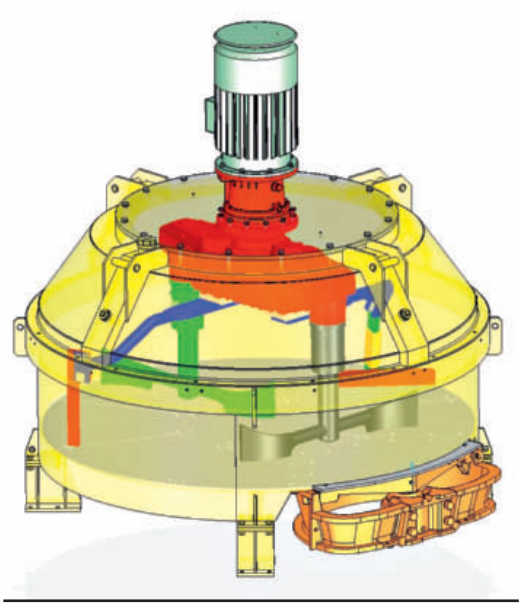
The point "Verlegesysteme Fliesen-, Platten und Natursteinverlegung" (laying systems for tiles, slabs and natural stone) holds comprehensive information regarding the proper laying of interior and exterior surfaces – including those of swimming pools – as well as information about substrate requirements and jointing materials.

In the case of "elastische und textile Bodenbelägen" (laying systems for textile and resilient floor coverings), optimal solutions are provided for the laying of e.g. needle felt, rubber and linoleum coverings, design coverings, sports flooring and artificial turf conforming to FIFA specifications. The section "Parkett und Holzböden" covering parquet and wooden flooring not only contains information about the laying of these materials but also valuable tips regarding the substrate preparation for hard coverings. The company's systems and products for building protection, waterproofing and repair are explained under the corresponding menu points relating to waterproofing and the repair of canalisation and inspection chambers. The point "Abdichtungssysteme" (waterproofing systems), contains MAPEIPLAN, a set of innovative system solutions for reliable sealing of flat roofs – covering everything from green roofs and refrigerated warehouse roofs up to industrial rooftops.

The systems are explained step by step and the products suggested for each system can be clicked and opened directly as an information page. The Mapei website is thus a very rational tool that facilitates the work of everybody concerned with flooring and waterproofing, and helps them to achieve optimum building solutions and work results. The various sections of the website are constantly updated and adapted to the latest knowledge and trends.
www.mapei.com

TEKA

The optimum mixer for the dry building materials industry



At the BAUMA 2013, TEKA Maschinenbau GmbH presented for the first time its newly-developed TEKA high-performance turbine mixer series (THT) – the result of intensive product research and development work. The device is ideal for mixing all dry material batches such as dry mortar, cements, etc. and is suitable for a multiple range of aggregates and different types of cements used in the dry building materials industry. It is the mixer for the most difficult mixing tasks and the most diverse batch sizes.

The TEKA high-performance turbine mixer series (THT) with its patent-pending mix-turbine are specifically suited for many different dry material batches from fine to coarse aggregates for the complete range of mortar mixtures to very small fines used in cement batches. The mix-turbine with its "swing and throw" effect provides the customer with a very intensive mixing action while at the same time not destroying the composition of the particles, resulting in premium quality products for the end-user. In addition, the mix-turbine is coated with tungsten-carbide pieces in order to ensure a long life cycle before the mix-turbine needs to be re-coated.

All THT turbine mixers are suited with a frequency converter for the main drive motor. The standard frequency converter allows for different rotation speeds of the mix-turbine in order to provide optimal mixing effectiveness for each individual batch depending on the specific dry material to be mixed without destroying the composition of the aggregates. In addition, varying mixing intensities can be selected during the different stages of a single mixing cycle allowing for better mixing effectiveness during the dosing, mixing and discharging phases. This also ensures that the drive power is used to the optimum, which reduces the energy requirement to that which is absolutely necessary and results in energy cost reduction

The THT is able to mix even the smallest batch sizes with the same mixer. Tests have proven that batch sizes of less than 10 % of the maximum filling capacity of the mixer have been achieved, resulting in enormous product flexibility for the end-user and giving the customer the possibility to manufacture a diverse range of products. Due to the complete emptying of the mixer within the shortest possible times, the changing of batch materials and products from one batch to the next batch without long cleaning intervals is possible.

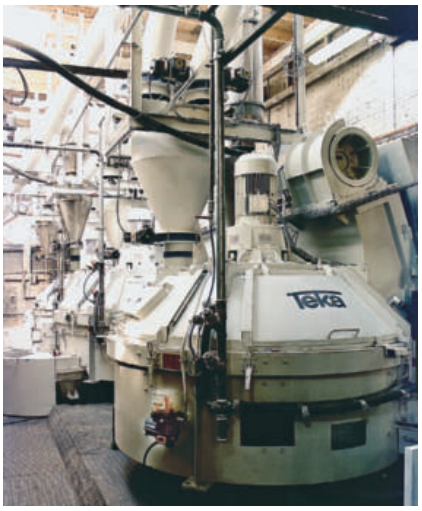
A further advantage is the reduction in contamination within the mixer itself. Not only the mix-turbine does have an optimal self-cleaning effect, but the fastening system for the mix-turbine runs outside of the batch. This results in longer intervals between cleaning and the effort required to clean the mixer is reduced to a minimum.

Thanks to the sophisticated modular system principle, the mixer can be configured optimally for the respective dry building material that is to be mixed. In order to optimally exhaust the possible combinations, a type designation was introduced for the new THT series that is no longer orientated towards the filling quantities, but rather to the specific requirements of the individual customer in combination with the required components.

In other words, turbine mixers are custom-built to the individual requirements and the specific mixing task. The drive power, the diameter of the pan and the number of mix-turbines are variable and specifically chosen for each single mixing task.

The advantages of the new THT series can be summarized as follows:

- the "swing and throw effect" of the mix-turbine ensures optimal material flow and intensive mixing action without particle destruction
- maximum flexibility with regard to grain size and batch size
- ability to mix even the smallest batch, leading to immense variability of batch sizes with the same mixer
- complete emptying of the mixer in extremely short times leads to larger batch variability
- no unmixed areas within the mixer, no "dead zones"
- possible points of adhesion for the batch material has been drastically reduced (for example installation bolts outside of the batch), which means considerably less contamination of the mixer
- the mix-turbine is coated with tungsten-carbide protection for extremely long wear-life and cost reduction
- drive power optimally adapted to the batch which is to be mixed thereby very energy efficient
- a frequency converter for the main motor is standard for optimum rotation speed of the mix-turbine depending on the batch composition and batch size
- depending on the application and power size, the installation of a second mixing turbine is possible (from 1500 litres onwards)
- various mixing trough sizes up to a capacity of 3000 litres depending on the specific application



The mixing effectiveness of the mixers from the THT series has been scientifically tested and proven by the Institute of Building Process and Environmental Technology (IBU) in Trier. The new mixing turbine has already proven itself in practice at numerous companies in new installations and modernizations of existing plants.

Also, many customers have already used the TEKA in-house testing facility. This is available for clients who would like to prove to themselves the mixing effectiveness of the THT turbine mixer with their specific dry material i.e. batch.

www.teka.de

RETSCH

From finest powders to rocks

Retsch's line of sieve shakers is the most comprehensive offering with regards to sieving motions, measuring ranges and sieve diameters, thus covering virtually any bulk material – from agglomerating powders to solid rocks. Lately, two new models have been added to the range.

The new Air Jet Sieve AS 200 jet is particularly suitable for sieve cuts of powdered materials which require efficient dispersion and desagglomeration. The option to store up to 10 SOP and the automatic vacuum regulator (accessory) guarantee reproducible and meaningful results. Innovative features such as the Open Mesh function, the selection of the nozzle speed as well as optional use of standard 2" high test sieves perfects the new air jet technology.

With the sieve shaker AS 450 control, RETSCH have designed their first siever for 400 mm and 450 mm sieves which operates with a three-dimensional sieving motion. It can be used for dry and wet sieving. The optimized electromagnetic drive with Retsch's CET Technology allows for amplitudes up to 2.2 mm even with maximum loads up to 25 kg. This makes the AS 450 superior to all other known sieve shakers based on conventional electromagnetic or imbalance drives.

Retsch's sieving line is completed by high-quality test sieves and the evaluation software EasySieve®.

www.retsch.com

The new Air Jet Sieve AS 200 jet

KNAUF

Gypsum thin-layer plaster for machine application

All Knauf

Thanks to machine-processing, the thin-layer plaster Multi-Finish M Pro ensures the economical and efficient creation of high-quality surfaces

Modern walling systems often result in very smooth and precise surfaces even at the building shell construction stage. When such systems are used, there is hardly ever a need for thick-layer plaster, such as would be required for smoothing out an uneven wall structure. With the new thin-layer, machine-applied plaster called Multi-Finish M Pro, building materials manufacturer Knauf of Iphofen in Lower Franconia/Germany has developed a product which ensures the high-speed creation of perfect wall finishes. The M Pro is an extremely fine-particle, plastic-modified gypsum thin-layer plaster for machine application. It can be applied very economically and efficiently, particularly to large surfaces, using conventional plastering machines.

The newly-developed plaster is ideal for thin, full-surface plastering of both rough and even surfaces, such as concrete, plasterboard and rendering. The thin-layer plaster is intended for interior use, both for new buildings and for modernization work, to produce smooth surfaces of quality level Q3, as well as to create high-quality decorative surface designs.

With this new plaster, Knauf extends its well-proven Multi-Finish product family. Beside the machine-applied surfacer Multi-Finish M for layer thicknesses of 0–3 mm, the M Pro – also a machine-applied product – now covers the layer-thickness range of 2–8 mm. Thanks to the special additive materials, the new thin-layer plaster not only produces a perfectly smooth finish, but also easily evens out any wall-surface irregularities. The material's smooth consistency allows easy distribution and finishing, thus ensuring problem-free working.

Extremely economical large-area machine-plastering of wall surfaces that are already largely smooth – such as pre-cast concrete elements, existing layers of plaster or cleanly-placed precision blocks – can be achieved up to a surface quality of Q3 with a thin layer of M Pro. The product is also ideal for closing joints between pre-cast concrete elements, as well as holes or slits. For a plastering contractor, this represents a saving in both time and material, and does not require the purchase of a special machine: the dry mortar can be processed using the classical PFT G4 plastering machine, or – for instance – the PFT Ritmo or the new PFT G 4 neXt generation. Used in combination with the Knauf Aton barrier primer, the new thin-layer plaster is also ideal for the full-surface sealing and filling of plasterboard up to a surface quality of Q3.

www.knauf.de

Sika Adds Value to Your Dry Mortars

If production of consistent, high quality yet economical dry mortar formulations is your goal, Sika's ViscoCrete line of products is your solution. To ensure the desired application and end-product properties, today's dry mortars need to be balanced multi-component systems in which each ingredient has to perform reliably.
Sika offers you professional technical support, functional service and the delivery of high-quality products, tailored to achieve your specific requirements.
Our additive solutions include **Sika**® **ViscoCrete**® Powders – these extremely efficient superplasticizers are tailored for applications like self-leveling and pumpable screeds as well as underlayments, non-shrink grouts, repair mortars and renders.

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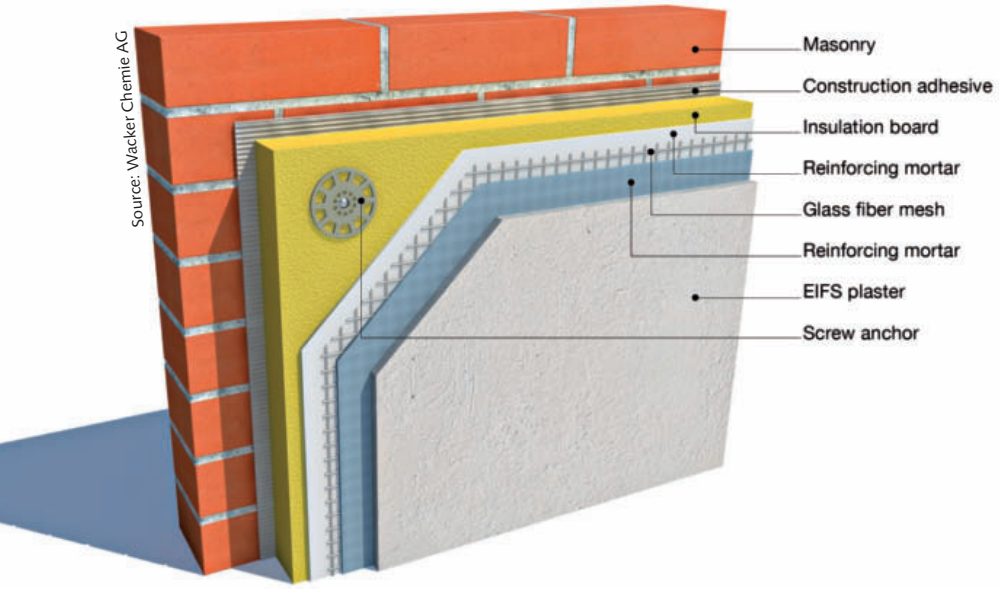
WACKER

Saving energy and cutting costs with innovative construction chemistry



Modern external thermal insulations composite systems (ETICS) for building insulation consist of a multi-layered material composite of carefully matched components. The addition of dispersible polymer powder to the mortar is essential to create a firm bond to the insulating material and thus a permanently stable insulation system

The right kind of thermal insulation can reduce energy costs in the home by up to 60 %. Dispersible polymer powders can be used to create highly innovative, customized thermal insulation systems which ensure a comfortable indoor climate whilst at the same time encouraging a sustainable energy industry.

Energy demand throughout the world is on the increase, there's only a finite supply of fossil fuels and resources. And in winter especially, as freezing temperatures drive up oil and gas prices, we certainly feel the pinch. With the right kind of thermal insulation, however, it's possible to not only create a comfortable indoor climate, but also cut energy bills dramatically.

Space heating, air conditioning and hot water account for the lion's share of domestic energy consumption. This pattern is not about to change, since nobody wants to, or indeed should have to do without hot water and a comfortable indoor environment. Nevertheless, there are plenty of opportunities to curb domestic energy consumption.

External thermal insulation composite systems (ETICS) offer the simplest and most reliable means of combating energy losses in the home. The better a building is insulated, the less energy is needed to maintain a comfortable indoor climate. In addition, ETICS reduce temperature differences between indoor air and wall surfaces, thereby greatly improving the comfort level inside.

External thermal insulation composite systems consist of a multi-layered material composite. Insulation materials such as polystyrene, mineral wool or cork are generally bonded to the external walls of the building using special adhesives mortars, then finished with a special coating. Bonded systems are used to avoid creating unnecessary thermal bridges.

Source: Wacker Chemie AG

Technical Center: Applications modified with VINNAPAS® dispersible polymer powders are tested under a range of climatic conditions in the walk-in climatic chamber. The processing properties and stability of materials can be tested at temperatures ranging from -20 °C to +70 °C and at different humidity levels

Source: Wacker Chemie AG

Applying an ETICS: The reinforcing coat of glass fiber mesh is clearly visible on top of the insulation board. Particular care is taken to ensure that it is correctly installed at the corners

The important thing is that they bond well to the substrate. Mineral-based mortars by themselves don't actually adhere to modern insulation materials like polystyrene at all. A firm bond to the insulating material, resulting in a permanently stable insulation system, can be achieved only by the addition of specialized dispersible polymer powders. Just two to three percent of dispersible polymer powder in the mortar is sufficient for creating a durable and stable bond between the insulating board and the adhesive mortar. This, by the way, is true for improved adhesion to all substrates such as concrete, brickwork or wood-based material.

Starting from the wall, the first ETICS layer consists of an adhesive mortar that has been modified with dispersible polymer powders. The adhesive mortar evens out irregularities in the substrate and creates a stable bond between insulation board and wall. This bonding layer is followed by the thermal insulation board, onto which an adhesive coat consisting of a dry-mix mortar modified with dispersible polymer powder is applied. The polymer powder allows the mortar to adhere to the insulation board and gives it flexibility to cope with mechanical stress. A glass fiber mesh is then embedded in the adhesive coat to provide additional stability. The outermost layer is a decorative render or paint coat.

Modern ETICS greatly improve the quality of the indoor environment by reducing temperature differences between indoor air and wall surfaces. At the same time, effective insulation can noticeably reduce annoying drafts and prevent harmful molds from forming. Reduced use of heating and air conditioning also significantly improves the indoor climate.

Increased market value and reduced carbon footprint

External thermal insulation composite systems are ideal for anyone looking for sustainable energy savings. The higher energy prices rise, the more worthwhile energy-efficient home refurbishment becomes. Since ETICS may be incorporated into the design of new buildings and also used for the refurbishment of existing buildings, there's nothing to prevent retrofitting insulation.

In addition, ETICS significantly increase the value of a building by effectively protecting masonry against damp ingress and cracking. Last but not least, we must not overlook the fact that external thermal insulation composite systems help us to use our globally dwindling energy resources in a more balanced and sustainable way.

www.wacker.com

VINNAPAS® dispersible polymer powders

When it comes to the use of polymeric binders to modify the properties of cement-based systems, the Munich-based chemical company Wacker has led the world for over 50 years with its pioneering VINNAPAS® dispersible polymer powders. VINNAPAS® dispersible polymer powders are thermoplastics based largely on vinyl acetate and ethylene (vinyl acetate-ethylene copolymers). It was in 1957 that Wacker first succeeded in producing polymeric binders for the construction industry in powdered form. This achievement revolutionized the construction industry at the time by providing a one-component polymer-modified, cementitious mortar which required only water to be added on site. This greatly simplified the process of producing mortar and brought economic advantages which benefit the industry still to this day.

With VINNAPAS® dispersible polymer powders, Wacker has been involved in the development of external thermal insulation composite systems from the very start. Other applications for polymer-modified dry-mix mortars include construction and tile adhesives, self-leveling compounds and grouts, plaster and repair mortar.

Dispersible polymer powders bestow a wealth of benefits on the end product including ease of processing, very good adhesion to all types of substrate, increased flexibility and tensile strength and greater resistance to weathering. And since VINNAPAS® dispersible polymer powders are free from plasticizers and film-forming agents, they also feature low emissions.

TU MUNICH

"TUM Center for Advanced PCE Studies" opened

All ZKG International

1 The opening ceremony of TUM Center for Advanced PCE Studies took place at the Institute for Advanced Study, TUM Campus in Garching/ Germany

On 28.03.2014, the Technische Universität München opened its new "Center for Advanced PCE Studies" at the Faculty of Chemistry in Garching near Munich/Germany. PCEs (polycarboxylatethers) are comb polymers which are admixed to concrete to achieve high performance products such as self-compacting or ultra-high strength concretes. To this event, the leading global experts on PCE technology were invited and numerous guests from foreign countries including Japan, China and Russia joined in on this special day.

Prof. Dr. Wolfgang A. Herrmann, President of TU Munich, explained the reasons for opening a new center on PCE research. In his view, construction chemistry is an important pillar of the German economy. After all, 10% of global production in this area goes to the construction sector, in addition to the automotive industry. "The TUM is particularly suited for such a center, because it is the only university in Europe and North America with its own Chair for Construction Chemistry", Herrmann said.

The Vice Dean of the Department of Chemistry, Prof. Dr. Stephan Sieber, elaborated on the significance of the new center for the whole department.

Prof. Dr. Johann Plank explained that the new facility will give young researchers the opportunity to work in the innovative field of PCE superplasticizers and will enable them to advance this important technology. In this context, Prof. Plank introduced the first student at the center, Li Huiqun.

She will work on the clarification of the molecular structure of PCE polymers using ^{13}C NMR spectroscopy.

Additionally Prof. Plank said that the center represents a platform for knowledge exchange between academic fundamental research and industrial applicators. Thus, companies have the opportunity to conduct research projects e.g. by forming consortiums. The facility also provides the opportunity to educate specialists from the industry in PCE technology including synthesis, quality control and application.

For an even better understanding of superplasticizers, Plank proposed new institutions to be founded: A Global Forum for coordinating and planning industrial and academic research, a PCE Research Consortium with members from industry and academia, plus an Advisory Board to propose fields of research and advise the individual research activities and directions of the new TUM Center.

Next, the inventor of PCE superplasticizers, Dr. Tsuyoshi Hirata from Nippon Shokubai in Japan was awarded the TUM Badge of Honor for his pioneer achievement. Also, several companies which donated a significant amount of money to the start of the new centre were honored with the TUM badge and a commemorative insignia.

After the opening ceremony a symposium on the current status of PCE technology took place. Dr. Hirata started with his presentation "The Invention of PCE" in which he showed the strenuous way from the first theoretical concept of PCE to their market success. In October 2013, Hirata-san received the Hans-Kühl-Medal of the GDCh for his discovery of PCE at the 1st International Conference on Construction Chemistry in Berlin.

Dr. Norman Blank reported on "20 Years of Experience with PCE at Sika" and portrayed his experience with PCE at several construction projects in China and Europe, including the Shanghai World Financial Center and the new Gotthard Base Tunnel in Switzerland. In his opinion such ambitious construction projects could not have been realized without the application of modern PCE superplasticizers. In the future, he sees bio-based PCE made of molasses or corn becoming more important.

Dipl.-Min. Eugen Kleen from MC Bauchemie Müller GmbH in Bottrop reported on "PCE from the viewpoint of global application". He exemplified the enormous problems with PCE application in less developed countries in Africa or Asia. There, amongst other things, the inhomogeneity and the poor quality of the aggregates available and the resulting unpredictable PCE performance present a main challenge for applicators.

2 An international audience followed the lectures at the event

A highlight of the symposium was the contribution of Dr. Gerhard Crass (Clariant GmbH, Switzerland), entitled "Polyglycols as Macromonomers for PCEs from an Industrial Viewpoint". As representative of the world's biggest macromonomer producer he described the industrial synthesis of different macromolecules (MPEG methacrylate esters, allyl, vinyl and isoprenyl ethers) and their quality standards (e.g. the diol content). Additionally, he gave an outlook on the future development of the PCE market from Clariant's point of view.

The following presentation "The current situation and development of ether-based PCE macromonomers in China" by Prof. Zhu Jianmin from Liaoning Oxiranchem which is the largest producer of macromonomers in China, covered a

3 Prof. Herrmann, the President of TUM, is handing the key over to Prof. Plank

4 Intensive talks and discussions during the breaks

similar topic. He summarized the current status of the PCE market in China (production volume 2013 ~ 1.8 Mio. tons 20 wt. % solution) and the expected growth which is mainly driven by the construction of high-speed railway lines, of subways in the mega cities and of infrastructural projects, predominantly now in western China.

Similar experiences were reported by Prof. Kong Xingming from the Tsinghua University in Beijing in his presentation "History and future of PCE in China". There, the audience learned that PCE superplasticizers were introduced to the Chinese construction industry in a PCE symposium only 10 years ago. Nowadays, China represents the largest PCE market with roughly 500 producers.

In the last presentation "PCEs – What will come next?", Prof. Plank looked into the future of PCE technology. According to him, currently the biggest challenges for PCE technology are the incompatibility of PCE with specific cements and their sensitivity to clay contaminants. The latter problem can be found mainly in developing countries. Improvements can be made only via a deeper understanding of the molecular structure of PCE polymers as well as by the development of new monomers or new synthesis methods. Because of their excellent cost-performance relationship, Prof. Plank considers it unlikely for the near future that polycarboxylatethers will be replaced by a new type of superplasticizer.

The commemorative event closed with a gala dinner on the top floor of the building where participants had the opportunity for discussion with new and old acquaintances of the PCE community.

5 Group picture

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Polymer Powders
Polymer Dispersions
Primers
Reactive Fillers
Rheology Modifiers
Retarders
Shrinkage Reducers
Special Fillers/ Aggregates
Water Reducers
Others

2ND WEIMAR GYPSUM CONFERENCE, WEIMAR/GERMANY (26.–27.03.2014)

Gypsum is a superior binding agent

The 2nd Weimar Gypsum Conference held in Weimar on 26.–27.03.2014 was a complete success. It was attended by around 120 specialists from 15 countries. The event was planned and organised by the "F.A. Finger Institute for Building Materials Science" of the Bauhaus-Universität Weimar in collaboration with the German Gypsum Association (Bundesverband der Gipsindustrie e.V.) and the Russian Gypsum Association.

The conference was opened by Horst-Michael Ludwig (Chair of Construction Materials), who reminded the attendees that the Weimar Gypsum Conference had been created as "a forum for the broad exchange of ideas regarding calcium sulphate binding agents and their application". The focus of this conference had been placed on calcium sulphate binding agents, binding agent systems containing calcium sulphate, hydration and working, additives and their effect, calcium sulphate building materials and the preservation of historical monuments in order to equally address researchers and experts active in day-to-day industrial practice. Gypsum has established itself as a superior binding agent "because of its sustainability and outstanding CO_2 balance", Ludwig explained in his welcoming address. Calcium sulphate is a very interesting raw material for the manufacturing of Ca-S-Al cements, particularly because of its CO_2-reducing properties.

In the following presentations, Holger Ortleb of the Bundesverband der Gipsindustrie in Berlin, Christine Marlet of Eurogypsum in Brussels, and Yuriy Gontcharov and Alexander Buryanov (of Volgograd and Moscow respectively) discussed the general tasks, topics and objectives of the gypsum industry, and also described a central EU project (GtoG LIFE) and the status quo of the Russian gypsum industry, and its perspectives.

The numerous specialist lectures held during the event dealt with the properties of gypsum and its derivates, with new applications and possible uses as a building material and for restoration projects. Only a few of these lectures will be specially mentioned in the following.

Albrecht Wolter (Clausthal-Zellerfeld/Germany) showed the effect of additives in three-phase systems, such as gypsum, water and impurities. He stated that the design and evaluation of model systems is essential in order to gain an understanding of the interaction between PCE-based superplasticisers and stucco. The capabilities of a number of copolymers had been evaluated in order to determine which formulation would increase the productivity of a production line without being influenced by impurities. Subsequently, Hans-Bertram Fischer (Weimar/Germany) discussed the relationship between gypsum and water, before Daniela Freyer (Freiberg/Germany) spoke about the system $CaSO_4$-H_2O and presented an overview of the phase characteristics for the application.

Reinhard Trettin (Siegen/Germany) described the formation of anhydrite and the phase transformation of anhydrite III to anhydrite II, as well as the formation of insoluble anhydrite from slightly soluble anhydrite. It is conspicuous that the formation of insoluble anhydrite (dead-burned gypsum) occurs significantly later than the transformation of anhydrite III to anhydrite II, said Trettin. This means that an influence of the crystalline structure on the solubility is not solely responsible for the decrease in solubility.

Gerd Srocke (Halberstadt/Germany) presented his thesis that high-fired gypsum may be an old building material with a future. On the basis of publications dating back more than one hundred years, compared to findings that are currently put forward as being "new", but are – in fact – old, he clarified the significance of gypsum as a building material. Traditionally produced high-fired gypsum from a manufacturer of building materials has to contend like "David against Goliath" with "the prevailing ignorance or falsehoods concerning this material".

Subsequently, Heike Dreuse (Weimar) spoke on the subject of backfilling and repair mortar for plaster and stucco surfaces containing gypsum, as

All F.A. Finger Institute, Weimar

1 Almost all the seats of the auditorium were filled with attentive listeners

well as for ornamental stucco, before Hans-Werner Zier (Weimar) discussed the effects of swelling mineral formation in samples of mortar and cement pastes containing gypsum, and the consequences for masonry repair measures.

The first day of the conference ended with two lectures concerning gypsum machine-applied plasters. Jörg Neubauer (Bomlitz/Germany) explained the influence on lump formation of the dissolution time of cellulose ethers in an aqueous solution. Andreas Hecker (Weimar) spoke about the characterization of stuccos and assessment of their surface quality.

The second day commenced with a presentation by Yilmaz Sakalli (Siegen/Germany) about the investigation of nucleation in the system of calcium sulphates. Subsequently, Vadim Khozin (Kazan/Russia) spoke about high-strength composition binding agents for structural concretes.

Christian Pritzels' (Siegen) presentation concerning the strength development of gypsum and the decrease in strength following saturation met with great interest on the part of the attendees, as did that of Ying Wang (Munich/Germany) about her investigation of the water resistance of multi-component binding agent systems on the basis of FGD gypsum.

The subject of additives was addressed by the description of investigations carried out by Victoria Petropavlovskaya (Tver/Russia) into the structural modification of composite materials on the basis of calcium-sulphate-dihydrate and the lecture by Grigorij Jakovlev (Ishevsk/Russia) about improvements to the technical properties of gypsum binding agents by admixing ultra-dispersive and nano-dispersive additives.

The second day of the conference was brought to a conclusion by a lecture by Anna Thomé (Sempach Station/Switzerland) regarding gypsum-based knifing fillers and an improved usability of alternative sources of gypsum.

Reviewing the event, the organizers stated that it had fulfilled or even exceeded all expectations. The conference had been successfully developed into a forum with comprehensive exchange of ideas in the field of calcium sulphate binding agents and their application. The organizers had specially selected the subjects with the aim of meeting the interest of both research and development experts and specialists in the applications sector – and had clearly achieved this aim. Not only did scientists provide an insight into their work, but also building specialists reported on their experience.

A date for the next event in the form of the 3rd Weimar Gypsum Conference has not yet been decided. This year's attendees and all other interested persons will be informed in good time.

2 Some conference participants came all the way from China

3 Reinhard Trettin and Horst-Michael Ludwig are listening to the lecturers

4 Caught in a technical discussion

5 Albrecht Wolter (TU Clausthal-Zellerfeld) during his presentation

ANNUAL CONFERENCE OF DEUTSCHE BAUCHEMIE, AUGSBURG/GERMANY (27.06.2014)

Budgets for infrastructure measures far too low

Deutsche Bauchemie (the German Construction Chemistry Association) has continued to grow. During the association's annual conference in Augsburg, it was announced that further new memberships had brought the current number up to 126 companies – the highest number since the industry association was founded. The main focus of the conference was placed on the subjects of international networking, the consequences of European regulatory activities, and transport infrastructure as a prospective market for the construction chemistry industry.

The German Construction Chemistry Association is a member of numerous European industry associations and is also establishing its own office in Brussels. "This will raise our association's profile in Brussels and in Strasbourg, and also increase our influence with the EU institutions", said the association's Chairman Johann J. Köster in his speech at the annual general meeting. This appears necessary, because the large number of regulations governing the sectors of business law and the single market, as well as environmental protection and occupational health and safety are nowadays almost exclusively decided in Brussels and Strasbourg, and sometimes require quick reactions on the part of the association. For instance: the fact that the EU Commission amended Annex III of the Construction Products Directive, which contains the binding format template for the declaration of performance, means that the already created specimen declarations of performance, as well as the CE markings have to be adapted to the new requirements. Köster: "For our Managing Director Norbert Schröter and his team in Frankfurt, as well as the experts in our committees this means that the necessary modifications have to be made as quickly as possible."

Deutsche Bauchemie

1 Executive committee and section representatives of the German Construction Chemistry Association at the annual conference in Augsburg on 27.06.2014

A further major project for the German Construction Chemistry Association results from the Environmental Product Declarations (EPDs). The number of completed documents that can be downloaded from the association's Internet platform (www.deutsche-bauchemie.de) has meanwhile grown to over 180 specimen EPDs. The overall project will be concluded this year because almost all the specimen EPDs verified by the independent Institut Bauen und Umwelt (Institute Construction and Environment) for all the relevant product groups have been made available. This work carried out by the association has been positively registered by other bodies: "FEICA, the Association of the European Adhesive & Sealant Industry, and EFCA, the European Federation of Concrete Admixtures Associations, have informed us of their binding interest in transferring the national specimen EPD concept to the European level", Köster announced.

The first presentation in the lecture section of the annual conference was given by Michael Halstenberg, Min. Dir. a. D., who informed the members about new developments in EU building product law. It is expected that the European Court of Justice will hand down its judgement in the infringement proceedings EU Commission versus Germany, concerning the Building Regulation Lists of the German Institute for Building Technology (DIBt) before the end of 2014.

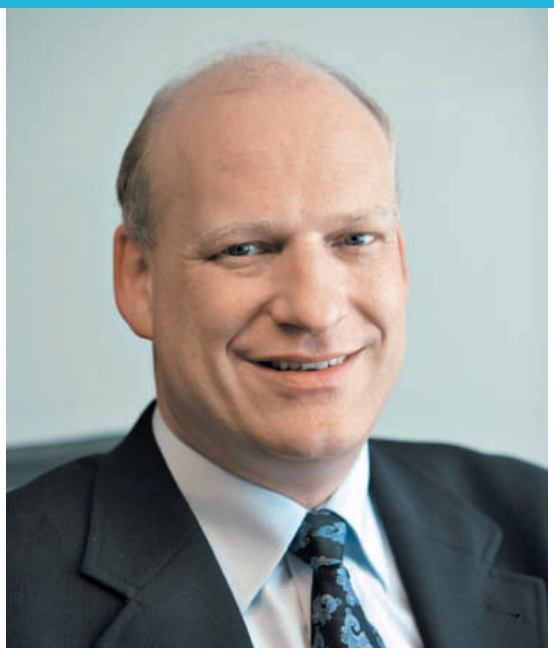
Prof. Dr. Dr. Franz-Josef Radermacher of the University of Ulm presented his model for an "environmentally responsible market economy and for sustainability". This model is essentially based on growth without increased consumption of resources, and functions under the precondition that global coordination and consensus processes are in place.

The former German Minister of Justice, Sabine Leutheusser-Schnarrenberger spoke on the subject of "Germany as an industrial location". She described what she regards as a present risk potential for economic success in Germany, due to a general "handout mentality", to new legislation such as statutory minimum wage and the pension package, as well as to data-protection deficiencies that also affect companies.

The next annual conference of the German Construction Chemistry Association will take place on 18/19 June 2015 in Baden-Baden. At the annual conference 2015 a new executive committee will be elected and the association will announce the new recipients of the Science Medal and the Sponsorship Award.

Deutsche Bauchemie

2 **Association managers and lecturers (l. to r.) Johann J. Köster (Chairman of the German Construction Chemistry Association), Prof. Dr. Dr. Franz-Josef Radermacher, Sabine Leutheusser-Schnarrenberger, Michael Halstenberg, Norbert Schröter (Managing Director of the German Construction Chemistry Association)**



Alfred Rockenfeller

GEMEINSCHAFT PAPIERSACKINDUSTRIE E.V. (GEMPSI)

"The paper sack is re-invented every day"

The paper sack is a generally established and well-proven packaging solution that has been in use for many decades. But precisely because of this long history, the paper sack is nowadays often regarded as an unsophisticated and outdated product. This image is unjustified, says GemPSI, the Gemeinschaft Papiersackindustrie e.V. (Paper Sack Industry Association), because the paper sack has undergone constant refinement in accordance with the rising demands placed on modern packaging. The industry's innovative strength and technological developments have made it into a sophisticated high-tech article with numerous positive characteristics that are perhaps not obvious at first glance. The product is indeed a real "sack full of ideas", which never ceases to surprise. Under this motto, GemPSI launched a promotion initiative at the beginning of 2014. What is behind this? Alfred Rockenfeller, Chairman of GemPSI describes current trends in paper sack production.

ZKG: *What is it exactly that makes the paper sack into a high-tech article?*
Rockenfeller: Firstly, the porosity of the employed Kraft paper, a feature which has been continuously improved over the years. This porosity enables problem-free venting during the filling process, without requiring complex and cost-intensive air extraction systems. The air contained in the sack simply escapes through the paper – naturally without allowing loss of the material being filled. This allows filling speeds of up to 6000 sacks per hour. The amount and cost of the paper used are further positive features that place paper sacks ahead of the field. Paper requirement per sack has been reduced by 25% in recent years – and that despite the fact that sack stability has remained the same or has even been improved. Depending on the particular product involved, the weight ratio of paper sack to contents can be up to 1:300. Hardly any other packaging product can achieve this efficiency. And that saves not only on sack material, but also on transportation costs. Another important point is that paper sacks are hardly ever standard products covering every possible application, but almost always are specially designed to suit the particular material to be packed before they are put into mass production – more or less comparable with a made-to-measure suit. We can therefore say that the paper sack is quasi re-invented every day.

ZKG: *Nevertheless, practical experience shows that the paper sack is inferior to other types of packaging when it comes to other important aspects like protection against moisture and shelf life. Are there any innovative solutions to these deficiencies?*

Rockenfeller: Protection against moisture has up to now been a characteristic that has been mainly associated with other packaging products. But that does not mean that the paper sack industry offers no solutions in this point. New developments in paper technology, in adhesives and in printing processes now mean that paper sacks also offer good protection against dampness and moisture. Such high-quality paper sacks can also be stored outdoors without risking softening of the sack or clumping of the contents during the first rainfall.

Moreover, particularly effective protection – even during especially adverse weather conditions – can, if required, be achieved by incorporating extremely thin plastic or aluminium barrier films into the paper sack. In combination with the resultantly improved stability of the Kraft paper, both types of barrier film enable filled paper sacks to be stored without problem for between 6 and 24 months – or even more.

ZKG: *What other prejudice concerning the paper sack would you like to dispel?*
Rockenfeller: It is often said that the paper sack causes problems of higher dust generation or reduced cleanliness. However, in reality a whole range of developments has eliminated these problems. Modern valve technology assures dust-tight sack closure and modern sack-opening systems prevent dust generation. This qualifies the modern paper sack for use even as a packaging solution for dusty products intended for application in areas that have to stay very clean during the processing.

ZKG: *Does that mean that the modern paper sack is unconditionally suitable for all bulk materials?*
Rockenfeller: Maybe not for all, but certainly for more materials than some people think. For each product there is a packaging solution that best meets the individual requirements. Selection of the most suitable packaging should always take full account of all the relevant parameters. In its entirety, the paper sack offers a unique combination of functionality, cost efficiency and environmental compatibility, paired with outstanding filling characteristics, good protection of the product and a wide range of design possibilities. This is an overall package that is second to none.

ZKG: *Thank you very much for this informative discussion.*

You can find further information about the paper sack as a versatile and future-oriented packaging solution under www.gempsi.de.

All HAVER & BOECKER

Burkhard Reploh and Robert Brüggemann (from left)

HAVER & BOECKER OHG

Packing of powder products into PE bags will become the standard

The Haver ADAMS® technology stands for the filling of bulk powder products with difficult flow properties into air-tight PE bags. After its introduction in 2005 the technology quickly established itself on the market. With the ROTO-PACKER® for small PE bags, Haver & Boecker from Oelde, Germany has now extended its weight spectrum so that bags with a weight range from 1 to 50 kg can be filled.

Both Product Manager Robert Brüggemann and Business Unit Leader Burkhard Reploh, experts at H&B on use of the Haver ADAMS® technology in the building materials and minerals industry, look back at the history of the technology and look into the future.

ZKG: *Just a few years ago nobody would have foreseen that building products and minerals could be filled into environmentally friendly and weather-resistant PE bags. How was this development achieved?*
Robert Brüggemann: A customer approached us with the wish to fill powder into air-tight PE bags. We took up the challenge and together we developed the Haver ADAMS® technology.

ZKG: *What exactly was the real challenge?*
Burkhard Reploh: For granulated and grainy products, packing with Form-Fill-Seal systems has been common for a long time. However, very fine powder products have very high dust content. At the same time compaction of the product inside the bag is the fundamental requirement to get a clean and efficient final result. PE bags for granulate products can be needled or micro-perforated to allow air escape. This is not possible with powder-type products because the product leaks out.
Robert Brüggemann: Using the given requirements we developed a completely new bag and filling concept. To do this we solved every technical challenge individually, checked them over thoroughly and developed a compact machine on that basis. Vibrating bottles and vibrating table or bottom vibrators provide the needed compaction. Thanks to micro-vibration air bubbles automatically rise inside the product.

ZKG: *What was the reaction of the building materials and mineral industry?*
Burkhard Reploh: The first experiences we had with the Haver ADAMS® technology were in the cement sector. At first the market was somewhat sceptical because the system meant changing the entire filling process with the FFS technology. However our customers quickly recognised the advantages of filling their powder-type products into PE bags. So the ADAMS® made its mark in the building materials and minerals industry. We shipped out the first ADAMS® system for the building products sector already in 2005.

ZKG: *What advantages does the customer get from filling into PE bags?*
Burkhard Reploh: First and foremost our customers appreciate the optimum protection their products receive, more security during extended storage, the greater cleanliness throughout the logistical chain, and durable packaging. Also, from a marketing standpoint, plastic bags offer additional advantages over paper bags. Plastic bags can be printed over the entire surface and in multiple colours with photo-quality images, product information and barcodes.

ZKG: *What makes the Haver ADAMS® unique?*
Robert Brüggemann: With the ADAMS® we offer customers a high performance system with a universal spectrum of applications and product-specific dosing and compaction systems (vacuum lance; patented vibrating bottle). It is also characterised by reduced height. Our systems are very compact in size. Haver ADAMS® systems require especially little film because of the efficient compaction function and the compact bags that result. This saves costs for customers.

ZKG: *How many systems has Haver & Boecker delivered so far?*

ADAMS® at the Lafarge cement plant in Cookstown, Northern Ireland

Burkhard Reploh: So far we have delivered approximately 70 systems in over 15 countries worldwide. For us it is especially important to offer comprehensive service during the installation and start-up phase, and later for maintenance and repairs. We support the customers on-site with highly qualified service technicians.

ZKG: *In which sectors are the ADAMS® systems being used successfully today?*
Burkhard Reploh: In addition to the systems for the cement, building materials and minerals industry, we have also delivered systems for the chemical industry. Fundamentally we work also with hygroscopic powders; this is where the advantages in filling into plastic PE bags really come into play.

ZKG: *What lies ahead concerning the development of the Haver ADAMS®?*
Burkhard Reploh: Once the first system had a possible speed of up to 1200 bags per hour, it did not take long before the customer wished for even higher speeds. We optimised the technology and now, thanks to a new filling module and continuous rotating system, we offer a high performance filling system with up to twelve spouts. In doing so, we combined our experience with our ROTO-PACKER® and the expertise we had in the Form-Fill-Seal technology.
Robert Brüggemann: At the POWTECH 2014 in Nuremberg our ROTO-PACKER® for small PE bags will be making its debut. This packing machine is based on the ADAMS® technology and fills for the first time powder-type products into compact and freely stackable small PE bags. The machine reaches a speed of up to 600 bags per hour for the first step, with a design target of 1200 bags per hour, and features a stepless bag weight selection of 1–10 kg. So with this packing machine for small bags, we are extending the filling weight spectrum. Here it is possible to fill into bags made from a tubular film, or into every type of prefabricated bag. Using an additional module, our customers can form the small bags directly from a flat film inside the ROTO-PACKER® system.

Small bags are sealed air-tight and are impermeable to the weather

ZKG: *Does Haver & Boecker offer potential customers the possibility of testing their own products and their packaging?*
Robert Brüggemann: In our R&D Center we test and analyse products for filling together with the packaging material. The technical equipment at this facility, which has carried out over 20000 various analyses since it was founded 60 years ago, allows us to find the most optimum solution through systematic filling trials.


In the R&D Center Haver & Boecker tests and analyses products for filling together with the packaging material

Burkhard Reploh: The product analyses and filling trials are always viewed positively by our customers. They appreciate that we are not only focused on only the machine technology, but also on the packaging and all parameters that play a role in filling. This underscores our expertise and creates customer trust in reliable performance that is supported by filling-trials.

ZKG: *What about the palletizing systems Haver & Boecker offers for filled PE bags?*
Burkhard Reploh: We have made linking our premium technology to form complete systems a top priority. For two years Newtec Bag Palletizing has supplemented and enriched our well-known product line-up with their automatic palletizing systems. The Haver palletizers made by Newtec are customised to suit the requirements of the Haver ADAMS® filling systems. Our customers get complete plants from a single source. This reduces possible interfaces and leads to greater communication efficiency.

ZKG: *How do you see the future of filling and packaging in the building materials and minerals industry?*
Robert Brüggemann: The packing of powder products into PE bags is becoming the standard and is seeing an even higher degree of acceptance by the market. End-buyers are opting for products filled in PE packaging or even directly requesting it because of their attractive store shelf appearance and other clear advantages, like cleanliness and protection from weather elements.

ZKG: *Many thanks for an interesting and informative interview.*

BEUMER GROUP/SCHWENK PUTZTECHNIK

Proper and sales-promoting stack configuration

1 Introduction

Dry mortar are prefabricated mixtures composed of mineral binding agents as cement, limestone, gypsum as well as sand, rock dust and further additives. On the building site the craftsmen have to mix them merely with water and they are ready for use. Owing to the avoidance of possible mixing errors, the producer can ensure a constant high product quality of this building material. Schwenk Putztechnik GmbH & Co. KG headquartered in Ulm is one of the leading manufacturers of sustainable and ecological dry mortar. The company has produced its materials for more than 160 years in seven ultra-modern plants. "We place great importance on presenting our products optimally in the building material trade," says Martin Markus. At Schwenk Putztechnik he manages the plants in Eigeltingen and Allmendingen (Fig. 1) in Baden-Württemberg. As regards the manufacturing process, the company focuses on trouble-free transport, palletising process and packaging.

2 Safe handling of bags

"Oprevious palletising solution caused considerable problems during the turning of bags," remembers Peter Richter, deputy factory manager in Allmendingen. "Due to jerky movements the bags were deformed and sometimes even torn," he says. The building material manufacturer was not able to ensure a proper and constant appearance of the palletised bags. Schwenk Putztechnik not only wanted to achieve an improved and steady stacking result, but also wanted to increase the production capacity, reduce the dust emissions and prolong the maintenance intervals.

During their researches for a suitable supplier, the building material manufacturer found Beumer Group. The single-source provider from Beckum

1 Mortar silos at the Schwenk Putztechnik plant Allmendingen

BEUMER Group GmbH & Co. KG

BEUMER Group GmbH & Co. KG

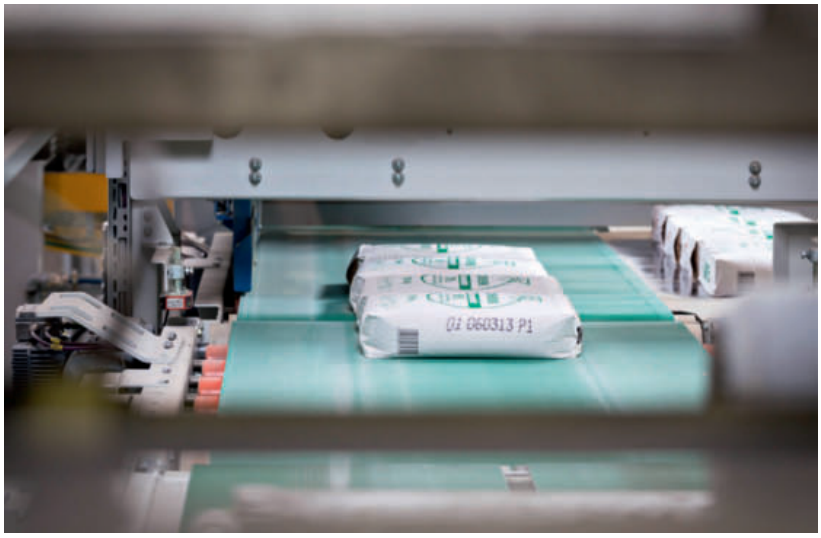
2 The twin-belt turning device: Two parallelly driven belt conveyors, which are driven with different speeds during the turning process, bring the bags gently into the required position

supplies sustainable systems for filling, palletising and packaging technology from one source. The leading internationally active company can look back on years of experience in the building material industry. "In cooperation with Schwenk Putztechnik we developed a solution which covers the requirements of both production plants," Peter Schmidt reports. As sales manager he was responsible for the project and has managed since January 2014 the Palletising and Packaging Technology business segment at Beumer Group.

3 Gentle palletising is ensured

Beumer presented the high-capacity layer palletiser type paletpac (Fig. 2) to the building material manufacturer. This construction series enables to stack bags filled with bulk material on pallets exactly layer by layer. Due to the geometric precision during layer and stack formation, stable bag stacks are formed. Beumer supplied a system able to palletise 1800 bags per hour as well as a system with a capacity of 2500 bags per hour. In both plants the employees can adapt the palletiser quickly and easily to different bag sizes without the use of tools. With a pack height of up to 2400 millimetres, the paletpac stacks bags on any commonly used pallet size and in all technically possible packing patterns. A multi-program interface enables the user to set parameters easily and quickly. The new Beumer Human Machine Interface (HMI) ensures a user-friendly operation of the system. This control terminal provides the employee with an easily understandable and intuitive interaction, enabling the user to learn the system very rapidly and to define efficient working sequences after just a short training and introduction period.

3 In order to reach a precise packing pattern dependent positioning, the intelligent control of the twin-belt turning device involves the physical properties of the items to be packed



BEUMER Group GmbH & Co. KG

4 Stable stack formation

"In order to turn the bags rapidly and gently to the required position ensuring their dimensional stability, the systems are provided with our newly developed twin-belt turning device (Fig. 3). In regards to the stackability, this device offers an immense advantage when compared with conventional turning processes," Peter Schmidt explains. The system component moves the bags without stressing them from a mechanical viewpoint. Instead, two parallelly driven belt conveyors are used, which during the turning process are driven with different speeds bringing the bags gently into the desired position.

The intelligent control of the twin-belt turning device involves the physical properties of the items to be packed in order to achieve an exact positioning preset by the respective packing pattern (Fig. 4) . In case of changes in bag sizes, all relevant parameters are registered and controlled just via software. For this, the system reverts to an active control loop. The regulation of the drives is carried out by frequency converters, thus developing a gentle, regular rotation and ensuring that the bagged products are not deformed. This results in constant stack results for the whole service life of the system. Ready packed pallets can be stacked on top of each other in space-saving and safe way.

A further advantage is that time-consuming modifications in case of changed bag sizes are no longer required. "The operator only has to enter the bag length and the bag width. Then the system brings the bag into the corresponding position," explains Bernhard Temming, service manager at Beumer. Thanks to the modular structure, the twin-belt turning device can be retrofitted even in already existing palletising systems in quick and trouble-free way.

BEUMER Group GmbH & Co. KG

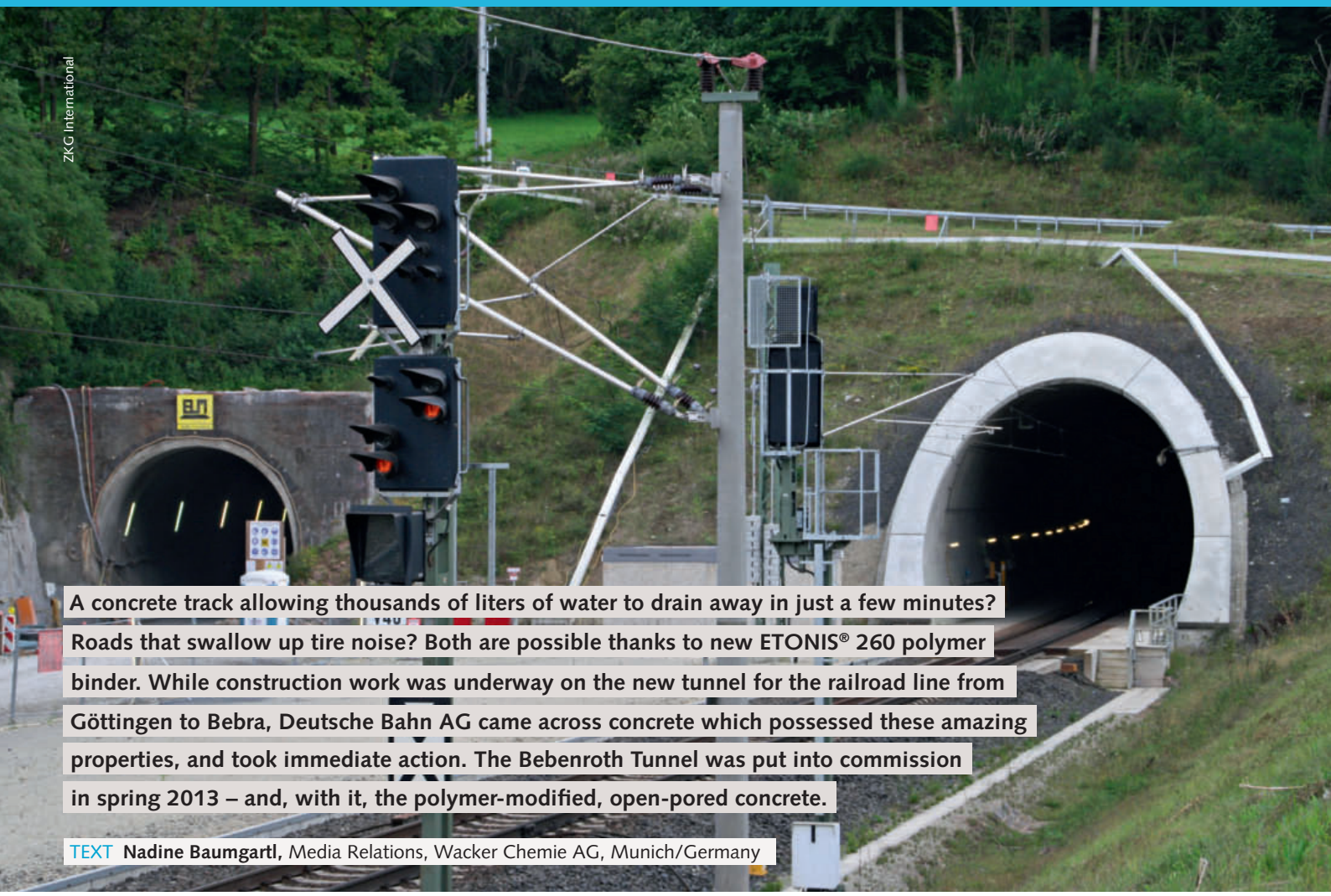
4 **The Beumer paletpac forms exact, stable and thus space-saving bag stacks**

5 Quiet and efficient

A further reason for Schwenk Putztechnik to opt for the Beumer systems was their efficient operation. In addition to capital costs, operational costs, spare parts costs and also maintenance costs play an important role. "These are better reduced with the twin-belt turning device than with other turning devices," recognises service manager Bernhard Temming. "The mere automated product change avoids idle times," and as the system component abstains from cost-intensive mechanical components, this optimises the maintenance and repair costs in the long term and reduces the life-cycle costs.

Comparable solutions of competitors for the layer preparation rely on pneumatic elements with correspondingly high operational costs. "In our twin-belt turning devices work is done by energy efficient synchronous servomotors," explains Temming. The relinquishment of mechanical parts additionally lowers noises during operation. Peter Schmidt is convinced that this is a strength that happens especially in the day-to-day operations, providing for an improved working atmosphere and inuring to the benefit of the skilled personnel of the building material manufacturer in the daily working sequence.

For this project Beumer took over the whole handling – from projection up to installation. The experts of the Customer Support were responsible of the optimisation and maintenance of the systems, therefore, they were always available. In case of acute problems, the building material manufacturer can contact the Beumer Hotline around the clock. An online connection with the machine permits to carry out a rapid fault analyses.



ZKG International

A concrete track allowing thousands of liters of water to drain away in just a few minutes? Roads that swallow up tire noise? Both are possible thanks to new ETONIS® 260 polymer binder. While construction work was underway on the new tunnel for the railroad line from Göttingen to Bebra, Deutsche Bahn AG came across concrete which possessed these amazing properties, and took immediate action. The Bebenroth Tunnel was put into commission in spring 2013 – and, with it, the polymer-modified, open-pored concrete.

TEXT **Nadine Baumgartl,** Media Relations, Wacker Chemie AG, Munich/Germany

The northern entrance of the Old and the New Bebenroth Tunnel

WACKER

New polymers for water-permeable concrete tracks: The Bebenroth Tunnel Project

1 Introduction

The Hockenheimring Race Track in mid September 2012. As the cameras roll, water gushes from a concrete mixer truck onto the track. Instead of spreading out or running off the surface, it drains away into it – "just like magic", as television presenter Aiman Abdallah will later report in the investigative program "Galileo". While researching one of its "Fake Checks" programs aimed at establishing the truth behind unbelievable internet videos, the television crew has encountered Siegfried Riffel from HeidelbergCement AG and the test section on the celebrated race track in Hockenheim. The test road link had been constructed back in 2002 from open-pored concrete, also known as drainage concrete. The Galileo team actually discovers that this open-pored surface coating swallows up more than 6000 liters of water, without forming a film of water on top. But then the surface coating is unable to absorb any more for a while. When asked why by the reporter, Siegfried Riffel explains by saying that the comparatively thin surface coating, just 8 cm, has been laid on a dense concrete underlay.

2 Research project for quiet traffic

Further open-pored concrete applications would follow starting in 2002 along the B 56 state road near Düren/Germany as part of the research pro-

ject "Quiet Road Traffic – Less Road Traffic Noise". However, there were problems with durability after several years of use along the project stretch: "The concrete composite underlay dislodged at numerous locations such that cracks emerged which led to road damage", Riffel explains. A further weakness would involve the open-pored joints' and bonding course's resistance to frost and road salt. "This is why it was necessary to develop a new and more long-lasting generation of open-pored concrete", he adds.

3 A new generation of materials in the railroad tunnel

Change of scene and time. About 25 km from Göttingen right beside the former inner-German border on 16.12.2012. The Deutsche Bahn Netz AG has organized a modest opening ceremony, mainly for representatives from the companies involved in the construction of the New Bebenroth Tunnel, which is 1030 meters long. Between and alongside the rails of the ballastless tracks of the design type "Rheda 2000" – this means the rails are fixed in concrete or asphalt instead of supported ballast – the roughly 16 cm thick surface coating inside the tunnel consists of flat, continuous, drainage concrete which works on the same principle as its counterpart at the Hockenheimring, minus the flaws. In close cooperation with HeidelbergCement, Wacker Chemie AG experts have eliminated the resistance-related deficits – to the delight of Björn Kunisch, who is representing the developer, Deutsche Bahn Netz AG. "This drainage concrete not only passed our water-permeability and fire-resistance tests, but can also carry emergency response vehicles with 10-metric-ton axle loads." According to a European safety regulation, new railway tunnels longer than 1 km must be easily accessible for rescue vehicles and fire trucks. Kunisch adds: "I am confident that the drainage concrete will prove extremely durable in service and that we have found a very good solution which meets the safety requirements for tunnels as regards accessibility."

3 Developing

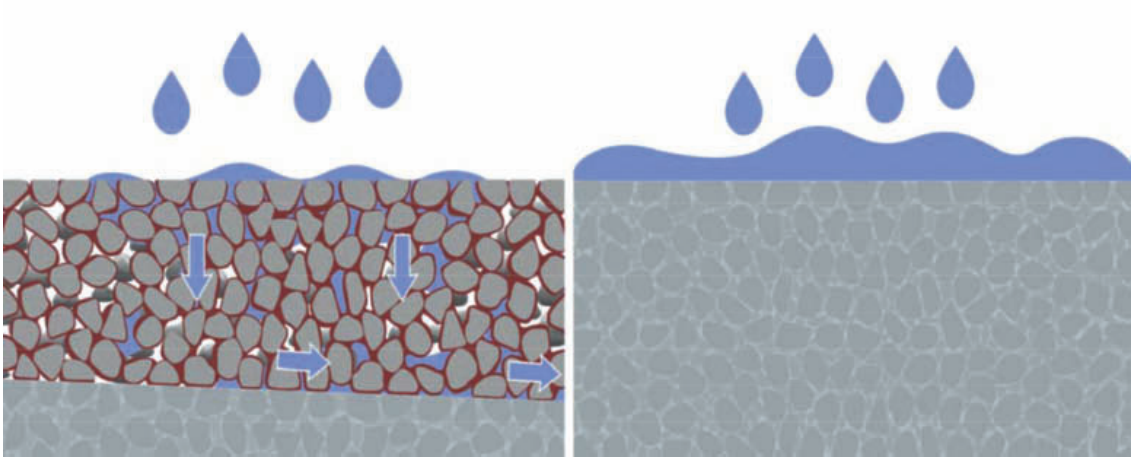
The drainage concrete or open-pored concrete as used in the New Bebenroth Tunnel first saw the light of day in 2008. At that time, Siegfried Riffel from HeidelbergCement AG contacted Wacker Chemie AG with a list of requirements for a new generation of concrete. Just three years later, the developers returned with a message: "Mission accomplished." The magnitude of the task and the speed with which it was completed are best appreciated by delving into the internal structure of the drainage concrete. The water is able to drain away quickly and easily through it because of the pores it contains: they make up some 15–20 % of it. Clearly, then, it is no easy task to render the drainage concrete as strong and as durable as normal concrete composed of a dense matrix of cement and aggregate.

Open-pored concrete is made with aggregate stones broken into cubes that measure 5–8 mm across and are thus roughly the same size. These gap-graded stones, as they are called, are responsible for creating the pores because they cannot be packed together densely. One way to understand this is to imagine the gaps in a jar filled with peas. Dense concrete, in contrast, is made with stones which vary in size, usually from 0.063–32 mm in diameter. Here, the smaller stones fill the gaps between the larger ones. In the jar of peas, for example, the gaps could be reduced by adding grains of rice.

"The individual aggregate stones of the open-pored concrete are completely enveloped by the cement paste and only bond to each other wherever they touch. In other words, they are only connected to each other by their edges, and weakly at that," explains Dr. Klas Sorger. The Wacker expert adds: "Without additional polymer binder, the stones would be plucked out from the surface when a tire rolls over it." Not only that, cracks would form readily in the material, because hardened cement on its own is too brittle without polymer; it is particularly vulnerable to frost and road salts, which can damage the bonds between the stones. Siegfried Riffel from HeidelbergCement explains: "For that very reason, we used a polymer binder for the first-generation drainage concrete. However, it took collaboration with Wacker to create a binder that critically improves the mechanical properties of the drainage concrete."

Wacker Chemie AG

1 Freshly mixed drainage concrete in laboratory trials: The open-pored structure and pores can be clearly seen. Thanks to the new ETONIS® 260 polymer, the non-slump fresh concrete does not flow or disintegrate at the edges – this is a vital prerequisite for level track surfaces



2 Water-permeability test: Open-pored concrete modified with ETONIS® 260 facilitates the transport of moisture (left), while on conventional solid concrete, water builds up and runs off slowly (right). This results in far fewer cracks forming in the new concrete and augments its resistance to frost and road salts

Wacker Chemie AG

When they started collaborating, the researchers first had to establish precisely what was wrong with the old recipe. "We subsequently developed ETONIS® 260, a polymer that is tailored in every respect to the application," says Sorger. High-performance polymer fibers were also added to the new drainage concrete to reinforce it (Fig. 1 and 2).

4 The Bebenroth Tunnel project

For Deutsche Bahn Netz AG, this development came at just the right time. In 2009, it decided that the old two-track Bebenroth Tunnel, which was built in 1875, was not up to modern standards on account of its sandstone brick lining. A straightforward renovation was not possible because the safety regulations stipulate that each track must have its own tunnel tube. Deutsche Bahn therefore decided to split the project into two parts. The first would be to build a new tunnel tube – the New Bebenroth Tunnel. Once it was connected to the important North-South freight line between Göttingen and Bebra, the second part would get under way: renovation of the old tunnel for subsequent use in one direction only.

"Originally, precast slabs were to be used to render the New Bebenroth Tunnel accessible to rescue vehicles," explains Ralph Pino, who was commissioned by the Project Construction Department of Deutsche Bahn to oversee construction of the New Bebenroth Tunnel. "But it soon became clear in the course of planning that it is difficult to dewater the tunnel with such precast slabs, especially lengthways." The water gets into the tunnel chiefly via the entrances. Added to which, it is swept in by incoming trains or forms condensation on the tunnel walls.

3 Drainage concrete modified with ETONIS® 260 is spread between and beside tracks and thus provides rescue vehicles and fire trucks with fast access to railroad tunnels. The new concrete is quick to put down, extremely durable and stable, and thus ideal for applications in road, tunnel and underground construction

Wacker Chemie AG, courtesy of Deutsche Bahn AG

As construction work on the tunnel continued, Deutsche Bahn Netz AG searched around for alternatives to the precast slabs, and discovered the drainage concrete. In a technical opinion, Prof. Stephan Freudenstein from the Technical University of Munich's "Prüfamt für Verkehrswegebau" (Test Authority for Traffic Route Engineering) recommended the developer use drainage concrete via the cast-in-place concrete process. That means that concrete is installed in site (Fig. 3–5). The alternative to the cast-in-place concrete process is delivery of precast slabs which, however, have various disadvantages. Following installation, these have joints and can shift due to mechanical stress.

Kunisch and Pino are united in their delight at how quickly and easily the drainage concrete track can be installed – it took just ten days in the case of the New Bebenroth Tunnel. And they also stress that the open-pored concrete can be very readily adapted to deviations within the construction tolerances. Ultimately, "if the rails and track are ever damaged, such as in a derailment, the drainage concrete can be removed and repaired much faster than precast elements," notes Pino.

5 Outlook

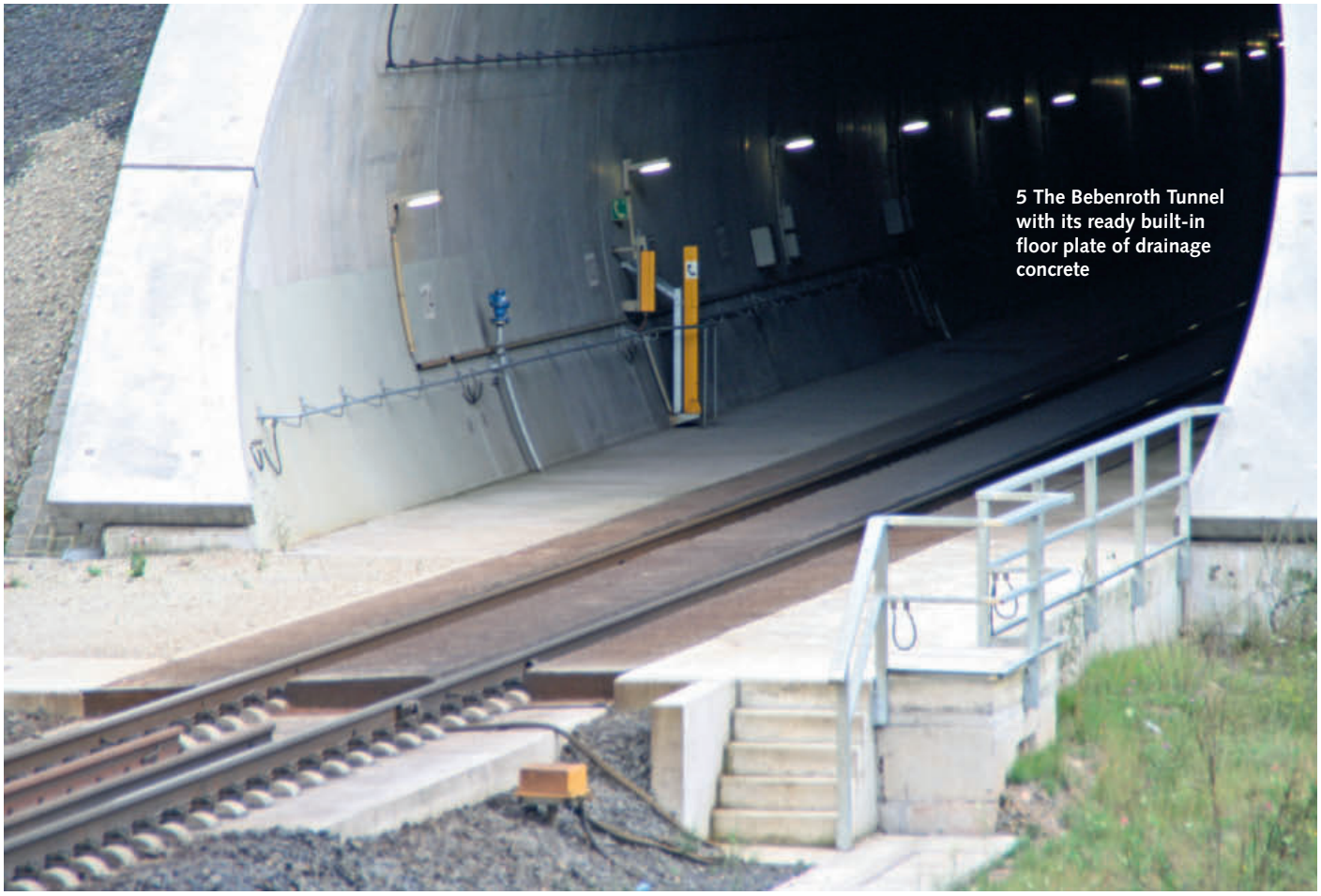
The future of the new polymer-modified drainage concrete looks rosy – not only because it will likely soon be used in the Old Bebenroth Tunnel and other railroad tunnels. As the material's compressive strength and tensile strength in bending, resistance

to frost and road salt, and thus its longevity have vastly improved over the drainage concrete of the first generation, it can now at last be used in the application for which it was originally conceived. Originally, open-pored concrete was designed in the early 1990s as "whispering concrete". "Sound gets lost, as it were, inside the material's pores. Consequently, open-pored concrete is highly efficient at attenuating the noise of tires rolling over it," explains Wacker expert Sorger. When it comes to noise nuisance, the rolling kind becomes much more annoying than engine noise once a car is travelling faster than 40 km/h.

The German Federal Highway Research Institute (Bundesamt für Straßenwesen or BASt) intends to start testing the second generation, open-pored concrete. If these tests are successful, test stretches will be installed on German highways from 2014 on. And in its role as a sound absorber for the ballastless track, the open-pored concrete could well be used for rail lines outside of tunnels. The reason is that traditional ballast, which is good at damping noise, is unsuitable for high-speed trains. Intercity Express (ICE) train routes will therefore be getting their own ballastless track which, though not very sound-absorbent, but rather strongly sound-reflecting when built in the traditional way, would benefit from open-pored concrete. Wacker and HeidelbergCement already tested this back in 2010 in a joint EU research project "Urban Track". Open-pored concrete was successfully installed as a rail sound absorber at a railroad test section in Brussels/Belgium.

Wacker Chemie AG

4 Test section of drainage concrete. While the water builds up on normal concrete or asphalt and runs off slowly (right side of photo), it can drain away easily and quickly on the new drainage concrete (left)



ZKG International

5 The Bebenroth Tunnel with its ready built-in floor plate of drainage concrete

TEXT **Dr. Petra Strunk**, Editor-in-Chief of
AT MINERAL PROCESSING, Gütersloh/Germany

Overall view of the dry mortar plant

ADEPLAST®

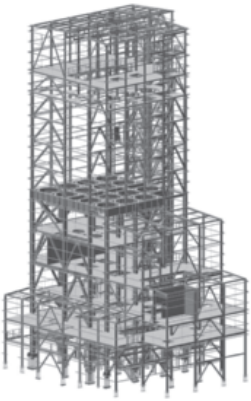
Dry mortar produced according to the state of the art

Oradea – a town in Northwestern Romania, near the Hungarian border, is the birthplace of Adeplast, a Romanian group of companies. In 1996, Marcel Bărbuţ became the majority shareholder of the company established in 1994 under the name Multistar Prod S.R.L. and transformed it into a Romanian-Austrian company. The link to Austria is obvious with Marcel Bărbuţ – after all he worked many years in Austria and, as he says, he learned a lot there. Focus of the company, which sells its products under the brand name Adeplast®, is the production of adhesives for ceramic cladding, polishing plasters, floor levelling compounds, industrial floor tiles and mechanically applied mortars.

From then on, the company began to grow. In 2004 a dry mortar factory was opened in Oradea. In the meantime, the Group owns three production sites, which, located in a large triangle, can supply the entire Romanian territory.

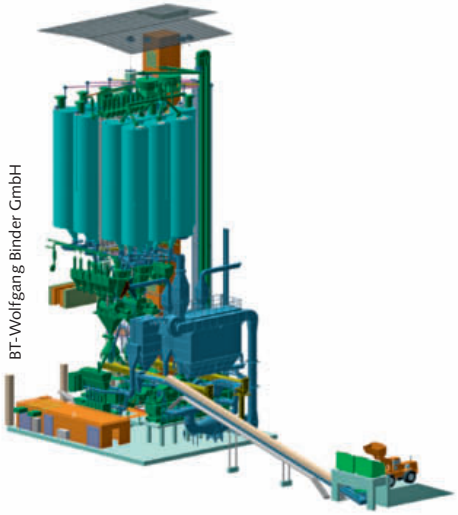
Oradea with a production capacity of 250 000 t dry mortar and adhesives, 50 000 t paints and decorative plasters per year and 700 000 m³ expanded polystyrene (EPS) – the first plant in the group in companies. In addition the northwestern site is the only site at which grey polystyrene is produced in collaboration with BASF.

Ploiesti is located near Bucharest in Southern Romania, with a capacity of 450 000 t dry mor-

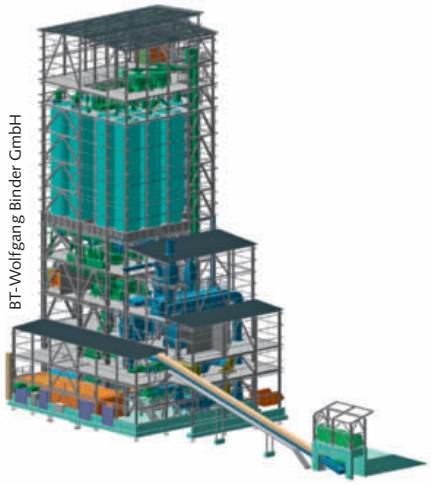


BT-Wolfgang Binder GmbH

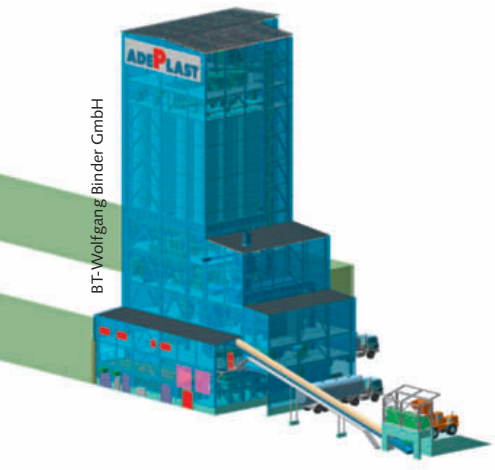
3D representation from the shell of the building to the finished factory



BT-Wolfgang Binder GmbH



BT-Wolfgang Binder GmbH



BT-Wolfgang Binder GmbH

tar and adhesives, 700 000 m³ EPS and 50 000 t paints and enamels per year. The dry mortar plant went into operation in 2008.

The latest site is located in the city of Roman, up in the northeast of the country. With the opening of this third site in August 2013, Adeplast became the Number 1 manufacturer of thermal systems in Romania. 450 000 t adhesives and dry mortars and 700 000 m³ EPS will be produced here in future when the plant is operating at full capacity. Initial difficulties with one of the main water pipes running through the site for the supply of Roman needing to be moved did not deter Marcel Bărbuţ: "Problems are there to be solved." Following the successful installation of sand drying and processing plant in Oradea, Bărbuţ chose the Austrian company BT-Wolfgang Binder GmbH as a general contractor. The plant was completed in just five months or 15 to 20 000 assembly hours and is one of the most modern dry mortar plants. One month after commissioning, production began in August 2013. In the meantime 65 people work at the plant in Roman.

The dry mortar plant has two production lines: one for cement-bonded and one for gypsum-bonded products. The daily production capacity is 1000 t/shift, 60 % cement-bonded and 40 % gypsum-bonded products being produced.

One of the most important starting materials for the production of dry mortar is sand in different grades. This is supplied from sand pits, with a moisture content of 8 to 10 %. In the sand storage, in which up to 3000 t can be stored, the upper layers of sand dewater to a water content of 5 %. The rest is done by a vibrating dryer/cooler, which dries 50 t sand per hour to a moisture content of 0.2 % and cools it to below 50 °C. Continuous moisture measurement at the belt feed to the dryer/cooler and at the dryer/cooler discharge constantly delivers actual values, which are then used to optimize the dryer control by means of the central plant control system and helps to save energy.

Upstream of the dryer, the sand is sent via a distributor feeder so that the entire width of the dryer is used. Drying is performed at a temperature up to 500 °C.

The gas burner is controlled either externally by means of the central plant control system or directly from a burner control cabinet.

At the dryer/cooler discharge, the sand is sent over a lump screen to remove stones and other large impurities. A bucket conveyor is used to feed the sand into the tumbling screens and the screened sand is fed in discharge pipes into the appropriate sand silos.

The remaining raw materials and binders are delivered by truck and injected into silos or storage containers via injector pipes. The additives are supplied in big-bags or sacks and transported onto the platform by means of lift and hoisting equipment and then filled manually into the respective tanks. At the silo heads and additive tanks, there are silo top filters/bag filters for dedusting.

A total of 11 silos are available for the cement binder and 14 silos for the gypsum line. The raw materials are removed by means of a metering screw into the weighers and combined in the mixer according to the recipe. All screws are equipped with frequency converters for precision-accuracy metering.

Adeplast®

Adeplast®

Building shell of the factory

Every line has two main balances and two smaller balances for weighing the additives and one large and one small manual feed. When components have to be manually added, this is displayed on a terminal in the area of the manual feed. The balances are uncoupled from the cover by means of a compensator, with the lower tare weight, a higher weighing accuracy is achieved. By means of plant control, the recipe, metering sequence and mixing time are defined. In addition, for every mixture, a log is saved, so all mixtures can be tracked in the event of a complaint later.

Downstream of the mixer, the material enters a rotary distributor head – here the decision is made whether the material should go to the sack-filling plant (15 - 40 kg valve sacks), in small packages (1 - 5-kg sacks or big bags) or for truck loading. Depending on the type of packaging, the mixture is further transported in the storage tank for the in-line packers or on a belt conveyor for loose loading.

The filled sacks go automatically to two palletizers – one line for gypsum- and one for cement-bonded building materials. In the fully automatic plant 40 t/h or 40 pallets/h can be packed in each case. Before being palletized, the sacks are compressed so that they take up the smallest possible volume. In this step, especially the de-airing capacity of the sacks is very important.

With regard to plant control, BT-Wolfgang Binder GmbH works together with the Austrian control engineering company ESA, Elektronische Steuerungs- und Automatisierungs-GmbH. The software modules developed for this purpose run on current Microsoft operating systems and are connected to an MS-SQL database. With this, it is possible to connect to ERP systems and external plant components, like, for example, a packaging or palletizing plant.

All production data is reported direct from the individual stations to the database and managed there. Full transparency and control in all production steps from the acceptance of raw materials to processing of the finished products is ensured. Intelligent recipe management with cleaning matrix is part of the overall plant control. This automatically prevents, for instance, that after the production of coarse or dark products, no fine or white products can be produced without a cleaning cycle being performed first.

To ensure the correct function of the plant, the technical documentation for every machine and a maintenance programme are integrated in the process control. This automatically reminds the plant operator of any maintenance due. This gives both the plant operator and BT-Wolfgang Binder the certainty that maintenance is performed regularly.

Adeplast®

Mounting under wintery temperatures

Marcel Bărbuţ, Chief Partner of Adeplast®

During a visit to the factory, Dr. Petra Strunk, Editor-in-Chief of AT MINERAL PROCESSING, took the opportunity to talk to Mr. Marcel Bărbuţ, principal shareholder of Adeplast®.

Adeplast – what's behind the name?
Marcel Bărbuţ: Adeplast is a Romanian-Austrian company established by me and a partner in 1994. Over the years, Adeplast has developed into a leading supplier in the building materials sector in the Romanian market and neighbouring countries.

At the Roman site in Eastern Romania a new dry building materials plant went into operation one year ago. You selected BT-Wolfgang Binder GmbH as the general contractor for the construction of the new plant – what reasons did you have for this choice?
Marcel Bărbuţ: Adeplast has experienced rapid growth in the last years, and several new plants and productions sites have been built. On account of many less than positive experiences with the previous new factory builds, this time we decided to award the contract for the construction of the new dry building material plant to a general contractor. A general contractor is responsible for everything – from concept development to commissioning of the plant, so that we didn't have anything to do with the individual steps and the coordination of the scheduled dates.

Some time earlier, BT-Wolfgang Binder had successfully built a drying and sand processing plant for another Adeplast facility. In addition BT-Wolfgang Binder has lots of references in the building materials sector, in which it had proven itself a competent plant engineering company. The decision to realize this project with BT-Wolfgang

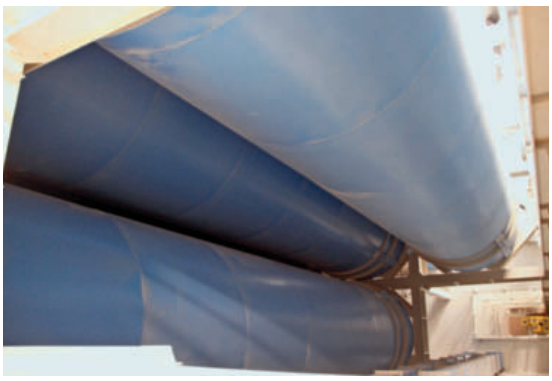
Installation of the plant components

Sand storage

Belt conveyor

Vibrated fluid bed dryer and cooler

Vibrating screens



View from the silos

Binder was correct – despite lots of problems with the local authorities, we got the plant up and running on time and to this day, one year after it was commissioned, there have been no serious faults or problems and we have been able to supply all our customers on time with our Adeplast products in their usual quality. For the construction work and the concrete engineering we contracted a Romanian-German building firm, whose work was also excellent.

How does the planning phase work with a general contractor?

Marcel Bărbuţ: We gave BT-Wolfgang Binder all key data like the number and type of raw materials and necessary throughput rates. In a number of project talks, we developed the plant concept together with BT-Wolfgang Binder. The ideas of Adeplast and the ideas of BT-Wolfgang Binder were fused into a joint concept. ln this project phase, the 3D design presentations from BT-Wolfgang Binder really helped us. Already in an early stage of the project, thanks to these 3D images, we were able to see the design with many realistic details and BT-Wolfgang Binder was able to take the wishes and requirements of technicians into consideration in the plant design.

Here the two models for the detailed steel engineering design and detailed machine design are nested so that collisions for pipelines, chutes and plant components with beams, supports, steel engineering assemblies are absolutely ruled out. This was particularly important for a lot of the material feed lines and cross connections between mixers and weighers.

What further investments are planned in dry building materials?

Marcel Bărbuţ: With the existing production sites, we are able to supply the Romanian market very

Silo filter

Injection of the raw materials

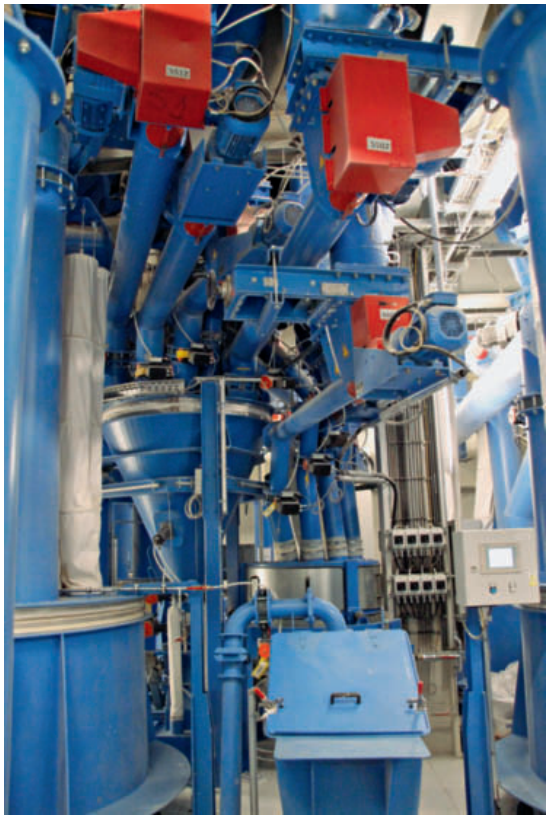
BT-Wolfgang Binder GmbH

Additive bins

Balances

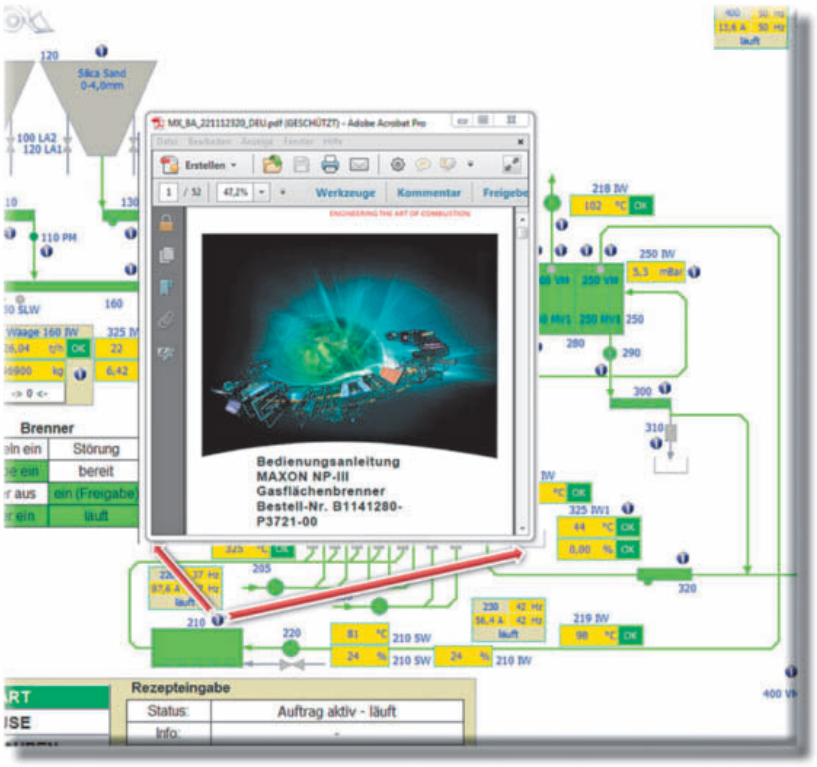
BT-Wolfgang Binder GmbH

Mixer



Dosing

Process control



The operating manuals for the different equipment are stored in the process control system

effectively and respond to customer requirements fast and efficiently. I have four sons, two of whom are already working in the company – we want to expand and I hope that my children will continue the business.

Naturally, increasing export of the products and production sites abroad are a goal for the future. We already have contacts to Saudi Arabia and Kuwait, there we deliver materials from the plant in Ploiesti. These countries are, however, relatively small. As soon as we have market shares in these countries, we are thinking about using the modular plant system from BT-Wolfgang Binder. This type of plant is relatively low-priced in terms of acquisition costs and it is possible to start production almost immediately. That is a super possibility.

How has Adeplast been able to grow steadily despite the crisis times?

Marcel Bărbuţ: We started up four plants last year. We are very good and effective in production, i.e. with regard to revenue per employee. We have good sites with an optimum geographic distribution over Romania. If the customers have a problem, they can ring us – we're always available. Before two years ago my personal telephone number was printed on the sacks in case someone had a question or a problem. Naturally, we also visit the customers and test the respective material and show them how to use it properly. So, at the end the customers are really satisfied with the result.

Many thanks for this interesting talk!

www.adeplast.ro

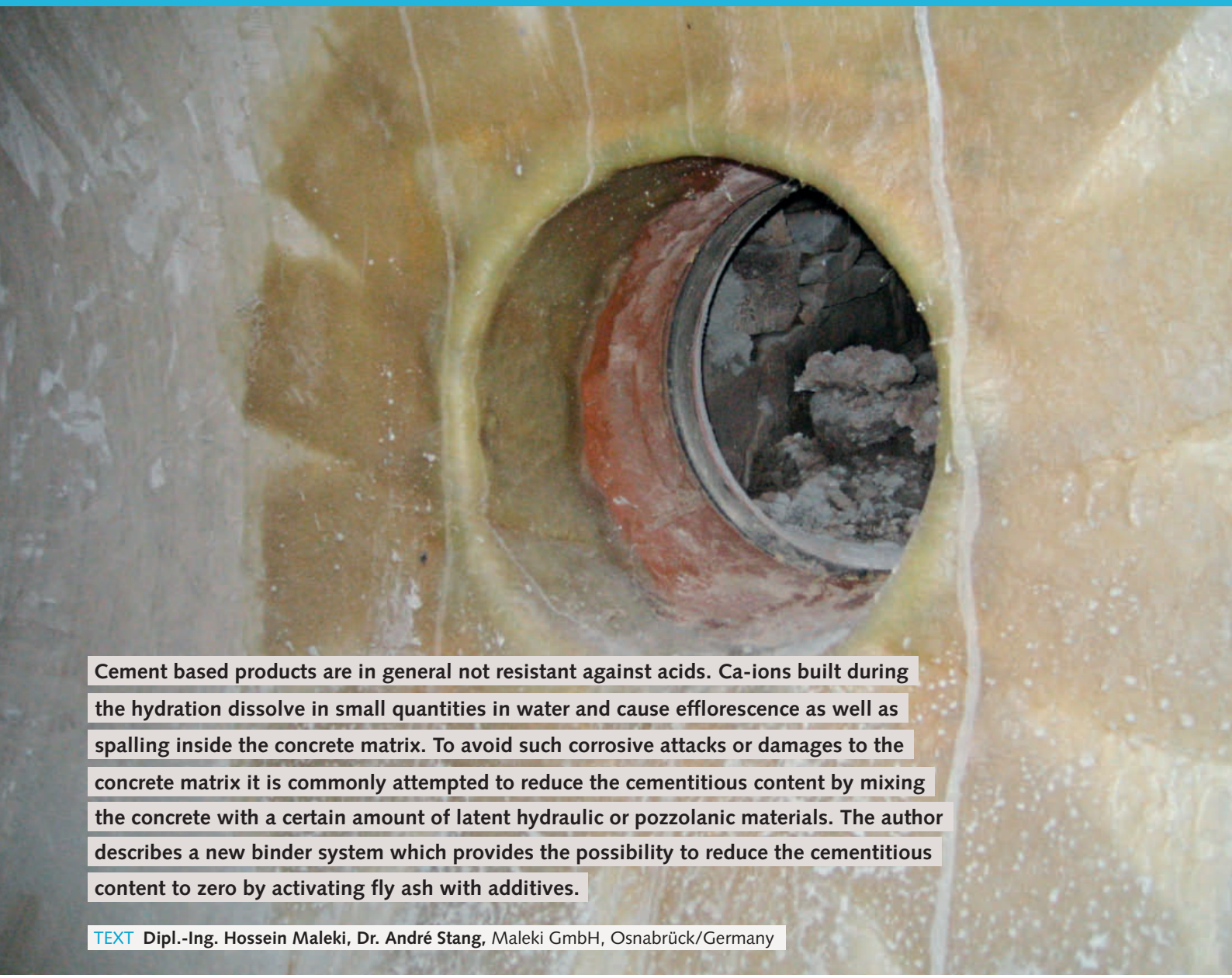
WEBINFO

On www.youtube.com – Search term: Mixing plant for dry building materials with sand processing – the plant can be visited by video!

Palletizer

Manager Ciprian Miron

Products



Cement based products are in general not resistant against acids. Ca-ions built during the hydration dissolve in small quantities in water and cause efflorescence as well as spalling inside the concrete matrix. To avoid such corrosive attacks or damages to the concrete matrix it is commonly attempted to reduce the cementitious content by mixing the concrete with a certain amount of latent hydraulic or pozzolanic materials. The author describes a new binder system which provides the possibility to reduce the cementitious content to zero by activating fly ash with additives.

TEXT **Dipl.-Ing. Hossein Maleki, Dr. André Stang,** Maleki GmbH, Osnabrück/Germany

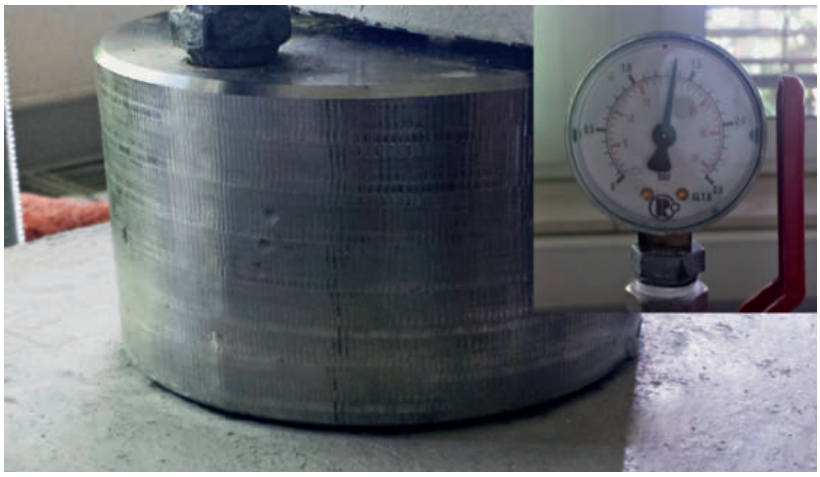
MALEKI

Innovative binder based on activated fly ash for products with chemical and corrosive load

1 Conventional systems

By using cement in a binder system for dry mortars or concrete the hydration of the different clinker phases provides the strength and the resistance of the matrix. To improve the properties of the matrix several latent hydraulic, pozzolanic materials and additives are commonly used that in the concrete provides a higher chemical or freeze/thaw resistance. One of these added materials is fly ash which has different effects on the concrete. Mainly the effects can be summarized by:

- rheological effect
- packaging/filler effect
- pozzolanic effect



1 Waterproofing effect at a pressure of > 1 bar

1.1 Rheological effect

While the rheological effect influences the workability and the water consumption because of the round shape of the particles, the filler and pozzolanic effect influence the resulting properties of the cementitious matrix.

The influence on the properties like chemical resistance can be explained by a combination of reactions which are caused by the second and third effect of the fly ash the "Packaging/filler effect" and the "Pozzolanic effect".

1.2 Packaging/filler effect

Fly ash provides an improvement of the packaging distribution because of very small particle sizes. As a result the capillary pores are reduced and the matrix becomes densified.

Further the empty space inside of the matrix is filled so that during the early stages of hydration and compressive strength development an increase of several percentages can be measured.

1.3 Pozzolanic effect

Beside the packaging effect the fly ash also interacts on the chemical level by a pozzolanic reaction. Fly ash contains amorphous silicon dioxide and aluminum oxide which react under room temperature with calcium hydroxide, produced by Portland cement during formation, and water to calcium silicate hydrate crystals. As a result the capillary pores and the reactive calcium hydroxide content are reduced and the chemical resistance is increased.

In many studies and approaches it was tried to enhance this reaction to reduce the Portland cement content to a minimum but still a lot of Portland cement is needed to activate the reaction. Therefore, cement-based mortar or concrete as commonly known are not long-term resistant in an acid environment with a pH of < 3,5.

2 Next generation of innovative binders

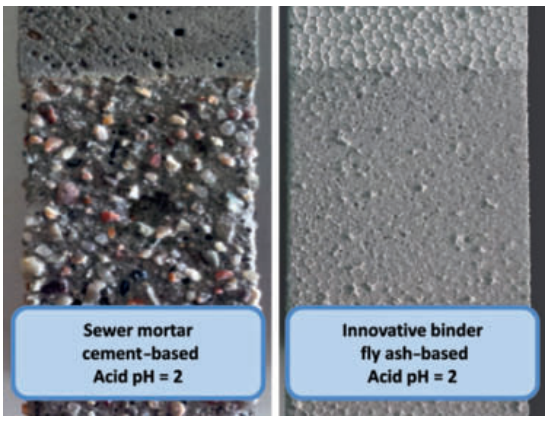
The latest knowledge in research of binder systems for dry mortar products to increase the chemical resistance and to avoid the usage of coatings like epoxy resins or other coatings for protection can solve the problem of poor resistance. Maleki from Osnabrück, Germany has approached this way by using a one-component and environmentally friendly binder system which is fly ash-based and which is cement free according to European standards.

In contrast to commonly used binder systems which reduce the Portland cement content by adding a certain value of fly ash, micro silica or substitute the Portland cement by alumina cement, the new binder system is based on fly ash activation. This activation mechanism is suitable for different fly ashes and supports the chemical reactions that form calcium silicate hydrates (CSH) and calcium aluminate silicate hydrate (CASH) which can be compared with the reaction of Portland cement during hydration.

The new binder system is adapted and stoichiometrically calculated that only CSH and CASH occur and nearly no calcium hydroxide is formed. This results in a dense structure and chemical resistance which is unreached by any mineral based mortar or concrete worldwide (Fig. 1-3).

An addition to the dense matrix the binder system provides additional benefits which are up to now unreached by any other mineral binder system. The formation of the CSH and CASH infects also the chemical resistance so that higher acid attacks can resist even long term. Compared to the one component silicate mortar of Maleki GmbH the resistance is less but still the fly ash binder is long-term resistant at a pH of > 2 (Fig. 2 and 3). The reason for the high chemical resistance can be found in the fact that the binder contains a huge amount of fly ash and nearly no calcium hydroxide is formed.

A further outstanding feature of the binder is that it is adapted to characteristics of different fly ashes. Therefore, the binder is suitable to be used



2 Comparison of a fly ash-based mortar and commonly used sewer system mortar sulfuric acid for 28 days at a pH of 2

as a universal binder for different types of fly ashes (Tab. 1). The results show that the compressive strength and flexural strength of three different fly ashes are comparable even by using the same binder composition without adaption. This can be explained by the composition of the binder which is adapted so that fluctuation of chemical composition of the fly ashes are covered and the chemical reaction can take place and finally the CSH or CASH are formed.

In contrast to the commonly used mineral binder system the innovative fly ash-based binder system provides a durability which was not possible up to now and can solve problems which were counterattacked so far by using the polymer coatings like epoxy or polyurea etc. Even new approaches can be discussed because it is not necessary to use a protective coating on top of a masonry mortar because the masonry mortar based on the fly ash binder itself can withstand the corrosive attacks for example in a sewer system and provides at the same time a waterproofing effect.

3 Conclusion

The new binder system generation of Maleki GmbH provides a long lasting and environmentally friendly solution to avoid the problems named in the introduction like their lack of acid resistance, formation of ettringite, salts and efflorescence of cementitious products. The common alternatives like epoxy resins, polymer coatings and highly developed mineral (cementitious) based products resolve these problems only rudimentarily.

With the 100 % inorganic and cement-free one-component fly ash-based binder system Maleki presents a binder system or solutions which do not suffer from the same disadvantages of the common epoxy or polymer coatings and highly developed mineral products.

Beside the advantages and benefits, the innovative fly ash-based binder is environmentally friendly because it is avoiding organic components, is produced by using secondary raw materials and is a high performance solution for corrosive areas at a low cost level with the following advantages and benefits:

- Fly ash based – cement-free according to European standards
- Applicable on a wet surface and at high humidity
- No hazard labeling required, non-hazardous
- No allergy potential and solvent-free, VOC-free, odorless
- Long term resistant to a pH of > 2 – 14
- No efflorescence and no harmful effects on concrete or masonry
- Easy handling by mixing with water, pumpable
- Low-swelling and low-shrinkage
- Eco-friendly alternative to epoxy resins or other coatings
- Environmentally friendly – very low carbon footprint
- Permanent solution of the protection problem of cementitious surfaces loaded with aggressive chemicals
- Suitable for channel, biogas plants, sewage treatment plants, manure tanks and all salt water, chemical loaded areas, hospitals, etc.

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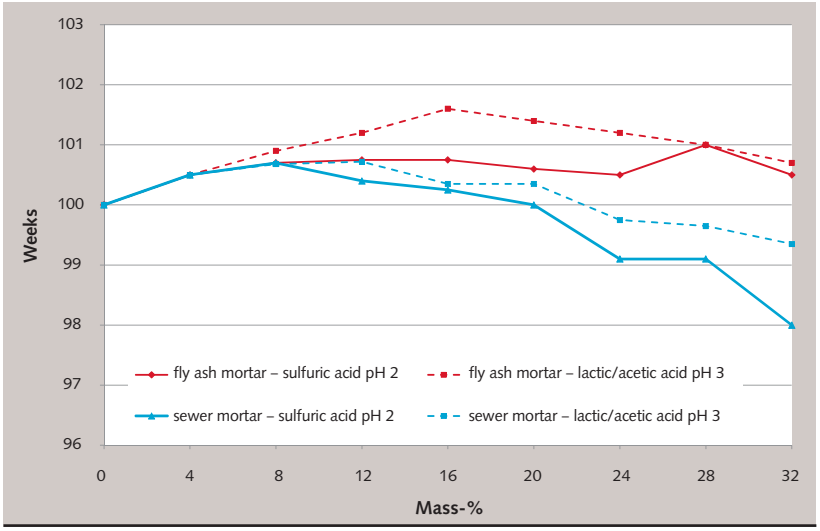

3 Comparison of a fly ash-based mortar, commonly used sewer system mortar, silicate mortar TPC 200 and SWP 270 stored in lactic/acetic and sulphuric acid for 280 days at a pH of 3 and 2

Tab. 1 Development and comparison of compressive strength and flexural strength of the fly ash-based binder system by using three different fly ashes from Germany, Belgium and India

Origin of fly ash		Germany	Belgium	India
Compressive strength [Mpa]	3 d	15,20	17,81	14,16
	7 d	26,70	29,01	20,79
	28 d	29,22	35,02	25,06
Flexural strength [Mpa]	3 d	3,75	4,15	3,30
	7 d	4,16	4,47	3,63
	28 d	4,87	5,13	4,09

Salt crystallization damage is one of the most common causes of decay for bedding, pointing and plastering mortar. Attempts to tackle the problem showed to often a limited durability to salt decay and a low compatibility with historical buildings. Recent research has shown new possibilities for improving the durability of mortars by engineering of the pore size, adding organic water repellent substances and salt crystallization inhibitors.

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DELFT UNIVERSITY OF TECHNOLOGY, DELFT/THE NETHERLANDS

Salt-resistant mortars: present knowledge and future perspectives*

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1 Introduction

Salt crystallization in porous materials constitutes one of the most frequent causes of decay of building materials, in a wide range of environment. With the foreseen effects of climate change, damage due to salt crystallization is expected to increase and intensify [1, 2]. Mortar is among the materials mostly affected by salt crystallization damage (Fig. 1).

The susceptibility of the mortars to salt damage originates from different factors:

» The fact they often constitute the moisture and salt transport network in historical structures

* First published in the 2013–2014 Yearbook of the Institute of Concrete Technology (ICT), Blackwater, Camberley, Surrey/UK, http://ict.concrete.org.uk

1 Salt damage in pointing mortar (left) and plaster (right)

and thus are heavily loaded by environmental agents;

» The limited internal tensile strength of mortars opposed to crystallization pressures;

» The bimodal pore size distribution of mortars, with both fine and coarse pores, which is favorable to the development of high crystallization pressures [3, 4].

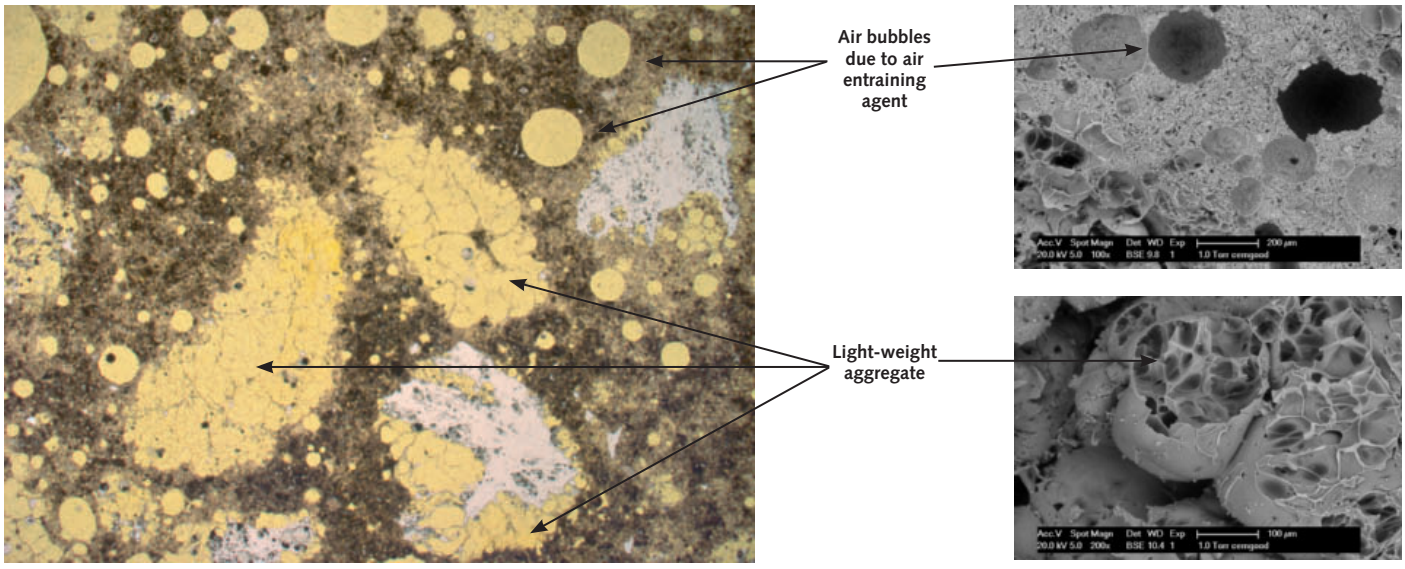
In almost all modern and historic buildings, mortar plays an essential role, either as bonding element between masonry units or stone blocks or – in a protective or aesthetic way – as render or plaster. The development of salt-resistant mortars, compatible with the existing fabric is therefore of crucial importance.

2 Present solutions to improve salt resistance of mortars

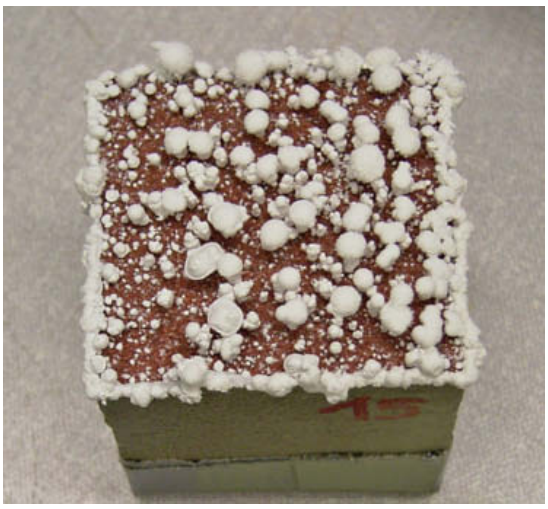
Solutions proposed until now to improve mortar durability to salt damage are not always compatible with historic buildings.

For example, the mechanical resistance of mortar can be increased by using cement as binder. Unfortunately, cement-based mortar has proven to be quite often not compatible with the existing fabric: the use of the cement-based mortar in restoration of cultural heritage has often caused a displacement of the damage, often into parts of the masonry of a higher historical and artistic value; it has also introduced a large quantity of new salts [5], enhancing the problem it was meant to solve.

Another solution that has been attempted aims at avoiding the ingress of water in the mortar, thus limiting the dissolution and transport of the salts. This concept is the basis for the so-called "salt accumulating" plasters and renders, containing (silicon based) water repellents mixed in the mass [6] These products have nevertheless the disadvantage of incorporating synthetic water repellents, which are not environmental friendly. Besides, due to their very strong water repellency, they often lead to salt accumulation beneath the mortar layer with subsequent detachment or to displacement of the damage to the adjacent materials.



2 Use of light-weight aggregate and air entraining agent in a salt-resistant restoration plaster



3 Crystallization of sodium chloride salt on brick in the absence (left) and in the presence (right) of crystallization inhibitor in the salt solution

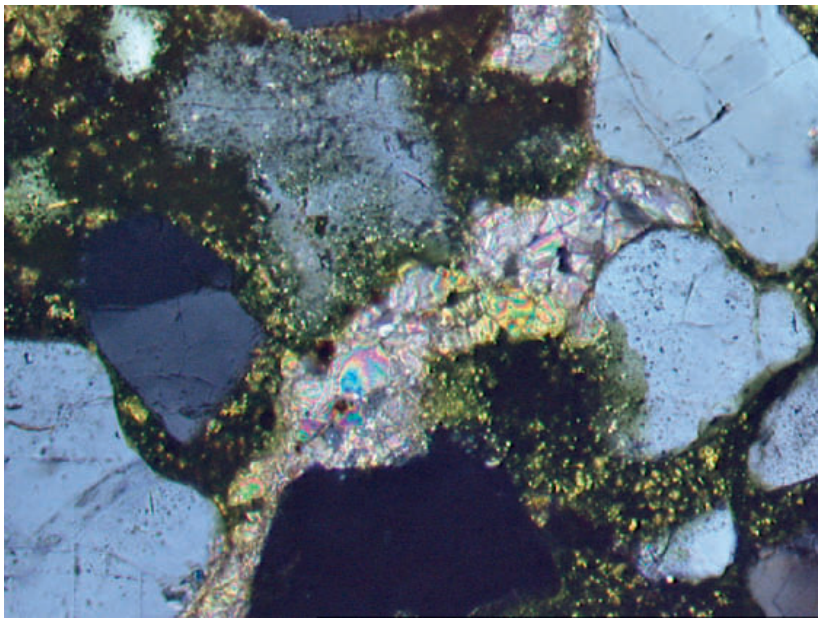
3 Future perspectives

The above-mentioned examples show that the development of new salt resistant and at the same time compatible mortars for bedding, pointing, renders and plasters demands immediate attention. Promising perspectives are offered by the following possibilities:

- Mortar with engineered pore size
- Mortar with mixed in crystallization inhibitors
- Mortar with enhanced self-healing capacity
- Mortar with slightly water repellent properties (natural water repellent)

3.1 Mortar with engineered pore size

A potential way of improving the salt resistance of mortar is engineering its pore size distribution tuning it to one less prone to develop high crystallization pressures.



4 PFM image showing re-precipitated $CaCO_3$ entirely filling a crack [200 x magnification (0.7 x 0.45 mm), plane polarized light (Defence wall, Den Bosch/The Netherlands)]

As earlier mentioned, mortars generally have a bi-modal pore size distribution with small (<1µm) and coarse pores (>100µm) which is favorable to the development of high crystallization pressures. Modifying the pore size distribution of the mortars towards a more unimodal one may improve the mortars' resistance to salt crystallization. The pore size distribution in mortars may be modified by using tensioactive agents, porous aggregates or grain size distributions of specific aggregate (Fig. 2). Besides, by engineering the pore size of the mortar the moisture and salt transport between the mortar and the other materials constituting the object can be controlled (e.g. [7]).

3.2 Mortar with mixed in crystallization inhibitors

The use of this type of additions to mortar may open interesting possibilities. Crystallization inhibitors are ions or molecules able to prevent or delay nucleation (nucleation inhibitors) and/or to reduce the growth rate of specific faces, thus modifying the crystal habit (habit modifiers). The addition of inhibitor in mortar might reduce the damage by enhancing crystallization of salts at the surface, in the form of non-harmful efflorescences (Fig. 3), instead of in the pores of the material [8]. Moreover, the change in crystal habit of the salt caused by the inhibitor seems to have a positive effect on the damage development [9, 10].

3.3 Mortar with enhanced self-healing capacity

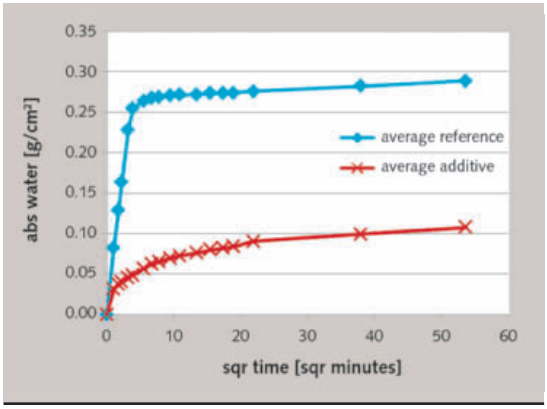
Lime mortars have, up to certain extent, a self-healing capacity that contributes to their durability: masonry built with lime mortars may show visible deformations without the mortar suffering any visible crack or serious decay. The self-healing process can be summarized as follows: moisture allows the dissolution of calcium hydroxide (in not fully carbonated mortars) and calcite (in carbonated mortars)

and transports them, from a zone rich in binder, to voids and cracks in the mortar. In this way small cracks may be filled with newly precipitated calcite, in a natural self-healing process (Fig. 4).

Further understanding of the mechanisms of self-healing in lime mortars and the definition of the conditions that favour this process may open new perspectives in improving the durability of lime mortars [11, 12].

3.4 Mortar with slightly water repellent properties (natural wr)

Another potential way to improve salt resistance of mortar is to mix additives into the mass. In ancient times natural additives (e.g. linseed oil, milk, casein, resin, etc.) were added to mortar as accelerators, retarders, plasticizers, aerators, adhesive, sealing and waterproofing agents (e.g. fat, oil, wax). In modern restoration plasters for salt loaded substrates, synthetic water repellents are often used to stop or reduce liquid moisture transport and delay the appearance of salt damage. These restoration plasters are strongly water repellent and may have a low compatibility with the existing fabric. Besides, most synthetic additives derive from crude oil and have an evident environmental impact.



5 Water absorption of mortar specimens without (reference) and with natural water repellent additive (average of three specimens)

Substituting the synthetic additives with natural additives may still provide sufficient water repellency to the mortar (Fig. 5) and open new perspectives for the development of durable, compatible and environmentally friendly mortars [13, 14].

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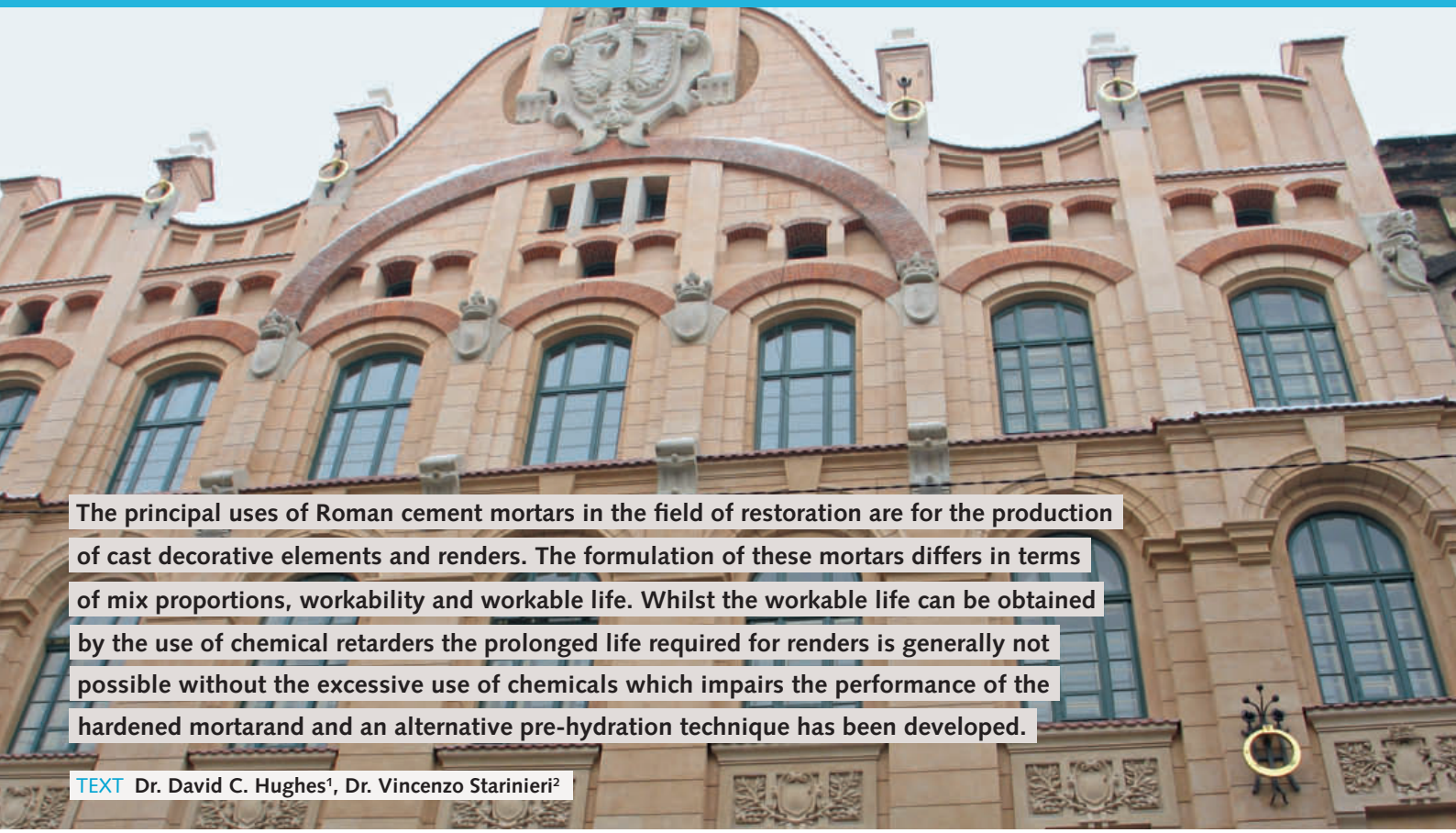

The principal uses of Roman cement mortars in the field of restoration are for the production of cast decorative elements and renders. The formulation of these mortars differs in terms of mix proportions, workability and workable life. Whilst the workable life can be obtained by the use of chemical retarders the prolonged life required for renders is generally not possible without the excessive use of chemicals which impairs the performance of the hardened mortarand and an alternative pre-hydration technique has been developed.

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Formulating mortars for use in restoration practice*

1 Introduction

A general introduction to the historical development of Roman cements within a European context, their composition and hydration may be found elsewhere [1–6]. A key point to reinforce is that Roman cement is a generic name, albeit one much despised by some 19th century authorities such as Pasley, covering a broad family of commonly rapid setting cements. As with all "natural" hydraulic binders, the performance of the calcined Roman cement is principally determined by the mineralogy and microstructure of the original marl or coastal septaria as was commonly used in the UK. Thus, it is not possible to define a "typical" Roman cement or Roman cement mortar and a restorer should work closely with the cement supplier to obtain initial guidance in the use of any unfamiliar cement. This paper describes various properties of mortars produced with three cements, i.e. Prompt (Vicat, France), Gartenau (Institute of Ceramics and Building Materials, Poland) and Wietersdorfer (Wietersdorf and Peggau, Austria). It should be noted that two Spanish companies, Tigre and Cementos Collet, are also able to supply a range of Roman cements, with the latter also supplying in the USA.

A study of historical Roman cement facades in several European countries was conducted during the ROCEM project [1]. It was found that mortars possessed higher cement contents than might be considered today and that a wide range of aggregate type and grading was evident. The cement content was higher in mortars for cast elements than for renders; the latter might also contain lime. Subsequently, the following specifications (Table 1)

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* First published in the 2013–2014 Yearbook of the Institute of Concrete Technology (ICT), Blackwater, Camberley, Surrey/UK, http://ict.concrete.org.uk

	Cast Elements	Renders
Mix proportions [by volume]	1:0.5–1:1	1:1.5–1:2.5
Flow [cm]	19.5	15.5
Workable life [mins]	15–30	60–120
Retardation	e.g. citric acid	DARC or citric acid

Tab. 1 Adopted mix proportions for investigation

were made for restoration mortars after input at workshops by representatives of the conservation industry including Remmers in Germany and Poland and Atelier Gurtner in Austria.

The specification for the workable life is exacting. Roman cements typically set within a few minutes; this is a distinguishing feature when comparing European Roman cements and American Natural cements. Consequently, for most uses retardation of the setting is essential. In order to meet the specification for cast mortars, chemicals such as sodium citrate, potassium citrate or, most commonly, citric acid may be used at dosage rates of some 0.5 % of the weight of cement. However, the specification for render mortars would generally require such excessive dosage of retarder that the performance of the mortar is severely degraded. A technique based on the pre-hydration of the cement with interesting consequences has been developed; the material has been called De-Activated Roman Cement or DARC. Latterly, it has been discovered that there is some historic basis for this approach although it is not known how widely practiced it would have been [7,8].

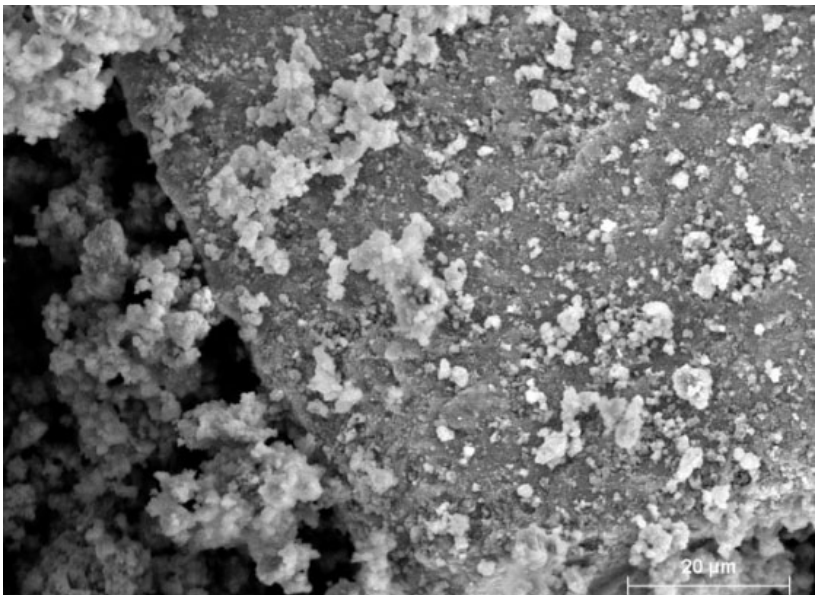
2 The DARC process

Full details of the research may be found elsewhere [9] and the following is necessarily a summary. The deactivation water is expressed as a percentage of the cement weight within any mortar and is typically in the range 7–10 % depending upon cement source. In order to obtain a uniform distribution of the deactivation water amongst all cement grains the water is first added to the dry sand and mixed for 2 min at 62 rpm (a Hobart mixer was used for all mortar production). Subsequently, the cement is added to the wet sand and the whole mixed for a further 2 minutes at 62 rpm. The resulting free flowing mixture is then stored in an air-tight container for various periods (storage times) until required for preparation of the mortar. This process generates hydration products initially dominated by monocarboaluminate ($C_4A\dot{C}H_{11}$) which is augmented by carbonated AFm as the storage period increases; these are the same aluminate phases produced in mortars with practical w/c ratios. Thus, it would be expected that early age strengths of DARC mortars would be low although this is not a problem for render applications. However, it has also been shown that the belite phases are not affected during the DARC process so long-term performance should not be compromised.

Figure 1 shows DARC (Gartenau cement) following de-activation with 10 % water having been stored for 30 minutes. The packing density of the aluminate phases increases with both the amount of de-activation water and storage time.

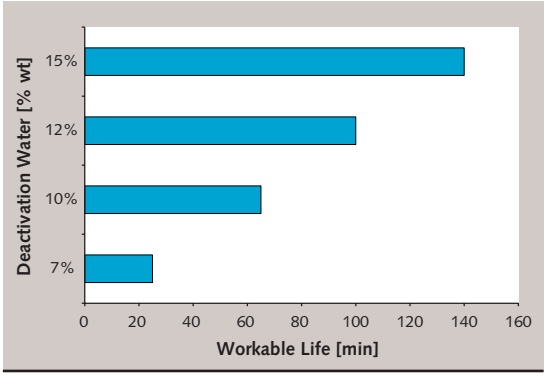
It is apparent in Figures 2 and 3 that the workable life is a function of both the amount of de-activation water and the time the dry mortar is stored prior to use on the façade. Thus, for a given cement the desired workable life may be tailored by a combination of these two parameters.

Figure 4 shows that the strength of a DARC mortar is essentially independent of storage times of up to 1 hour but then decreases for longer storage times up to 12 weeks. Thus, for a site produced mortar the DARC process does not impact on longer term strength. Further work in the laboratory has shown that the addition of quicklime, to combine with excess de-activation water, prevents the reduction in strength associated with prolonged storage periods, so opening the way to factory-based production of ready-mixed mortars suitable for subsequent distribution and storage. Trials are currently underway in Germany to produce such mortars. Figure 5

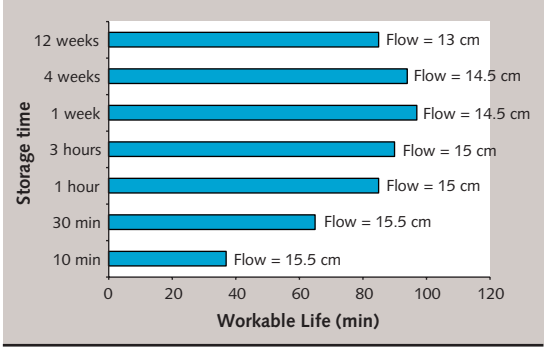


1 Surfaces of cement grain showing pre-hydration products

2 Influence of de-activation water on workable life



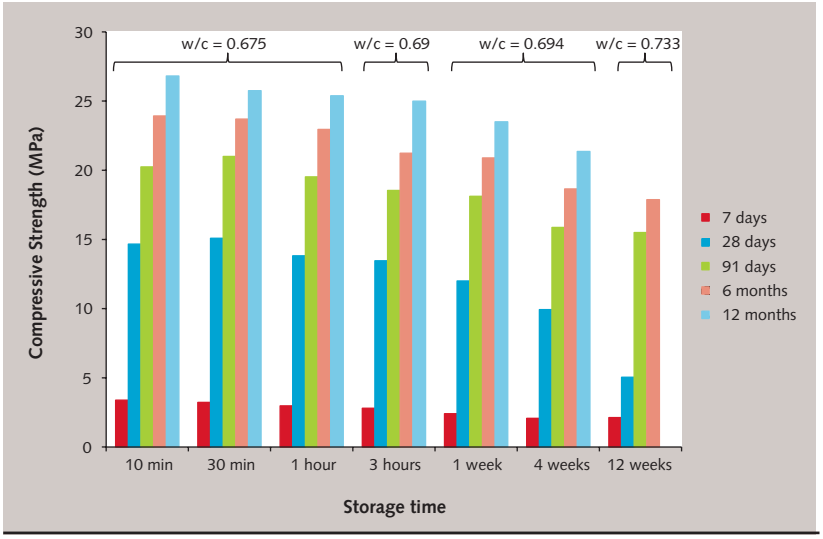
3 Influence of storage time on workable life



shows that whilst the strengths of the mortars with 10% and 12% deactivation water are similar, the strengths for the mortar with 15% de-activation water are significantly lower. However, it can be seen that the impact of de-activation water is lower on strength (Fig. 5) than on workable life (Fig. 2): whilst the workable life of the mortar with 15% de-activation water is double that of a mortar with 10% de-activation water, its strength is only reduced by some 13% at 28 days curing.

It was frequently advised in the 19th century literature that Roman cement mortars should not be re-mixed once the onset of setting had been observed. However, that is not the case with DARC mortars. Figure 6 shows the raw data, for a render DARC mortar using Gartenau cement, from the EN Workable Life test which specifies a penetration resistance of 1.5 kg as representing the end of the workable life of a mortar. At this point the mortar was re-mixed without the addition of any extra water. It is apparent that this process has extended the workable life from approximately 50 minutes to some 140 minutes. Samples were manufactured immediately after both first mixing and subsequent re-mixing. Figure 7 shows that the re-mixed mortar has a slightly finer pore structure at an age of 7 days. The re-mixing does not affect the strength development of the mortar whilst only marginally increasing the drying shrinkage as might be expected from a finer pore structure [9].

4 Effect of storage time on compressive strength of a DARC mortar after various ages of curing



3 Mortar properties

3.1 Casting mortars

Mortars of volumetric composition 1:0.5 and 1:1 were manufactured using Vicat's Prompt and two ROCARE cements, i.e. W&P Wietersdorfer and MBM Gartenau requiring citric acid concentrations of 0.5%, 0.4% and 1.0% of the weight of cement respectively in order to achieve the target workable life. A carbonate sand was used for all mortars.

The actual mortar strength will depend upon cement, mortar formulation and content of citric acid. Figures 8 and 9 show the likely envelopes for the mortars tested. The w/c ratio depends upon the characteristics of the cement but a value within the range 0.45–0.55 is a good starting point for trials. The lower curve in each case is typical of many Roman cements which exhibit a dormant period lasting days or weeks before substantial hydration is observed. It is known that Gartenau cement is particularly susceptible to excess retarder concentration and trials with a 1:2.5 mortar have shown that increasing the concentration of citric acid from 0.5% to 1.0% may yield a strength reduction of some 66%. Thus, it may be possible to raise the upper envelope but only at the expense of a shorter workable life for a given workability and formulation.

The early age strengths of the Roman cement mortars are higher than for both comparable PC and NHL 5 mortars making them ideal for cast elements requiring stripping at an early age. By way of comparison, for the 1:0.5 mortars at an age of 28 days the PC mortar achieved a strength of 43 MPa and the NHL 5 mortar achieved only 2.7 MPa, thus indicating the unique position of Roman cements within the continuum of hydraulic binders.

Breathability is an important yet poorly defined element of compatibility. It comprises the transport of both water and water vapour through

the mortar's pore structure. The Water Absorption Coefficient and Water Vapour Permeability after four weeks curing in water are more sensitive to the cement used rather than mix formulation. The WAC is higher than the value of 2 kg/m²/hr$^{0.5}$ considered critical for cast elements; the typical range may be 3–8 kg/m²/hr$^{0.5}$. This range compares to 2 kg/m²/hr$^{0.5}$ for Portland cement mortars and 25 kg/m²/hr$^{0.5}$ for an NHL 5 mortar. The range of values of WVP is 6–17 x 10^{-12} kg/m²/Pa/s. This range compares to 3 x 10^{-12} kg/m²/Pa/s for Portland cement mortars and 24 x 10^{-12} kg/m²/Pa/s for an NHL 5 mortar.

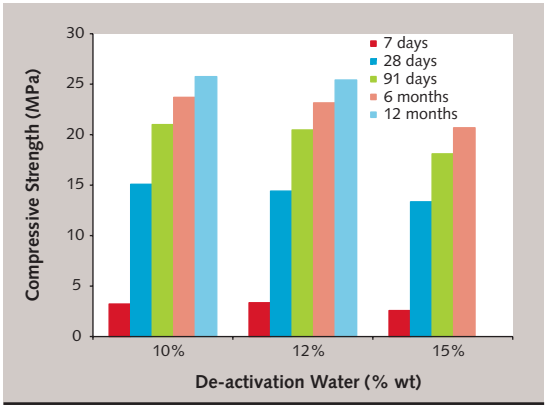
Associated with the transport properties is the porosity which in the case of the Roman cement mortars lies in the range 22–32 % with NHL 5 being higher at 34 % and Portland cement much lower at 13 %.

3.2 Render mortars

Mortars of volumetric composition 1:1.5 and 1:2.5 were manufactured using Vicat's Prompt and two ROCARE cements, i.e. W&P Wietersdorfer and MBM Gartenau and a carbonate sand. Whilst the Prompt mortars were retarded with 1.5 % citric acid which would often be considered to be excessive, the ROCARE mortars were retarded using the DARC approach. It should be noted that we have not been able to successfully use the DARC process with prompt and it has been suggested that this is because the DARC process is incomplete within a system which produces high water demand AFt rather than AFm as the initial hydration phase [5].

Figures 10 and 11 show data for render mortars manufactured with three different cements in order to illustrate key features. The mortar retarded using citric acid required 1.5% citric acid to achieve the specified workable life. Whilst the strength after six hours is low, it has rapidly developed strength at 24 hours. However, the high dosage of citric acid has also retarded the hydration of the belite phases which then show an acceleration between 91 and 180 days.

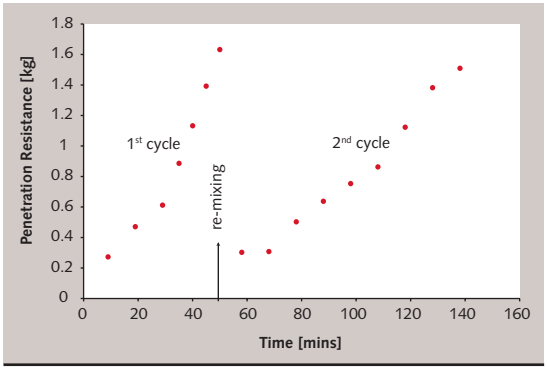
As expected, the DARC mortars possess low strength at one day; the DARC process produces the hydrates which would contribute to strength at this age which are then not able to be formed in the mortar. However, the strength then increases at a steady pace up to an age of 180 days when there is a narrow window within which the strength of all mortars is located. As previously observed for the casting mortars, mortars made with PC are much stronger than the Roman cement mortars and those made with the NHL 5 are much weaker; the strengths of the 1:1.5 mortars are 61 MPa and 6.1 MPa respectively at an age of six months.



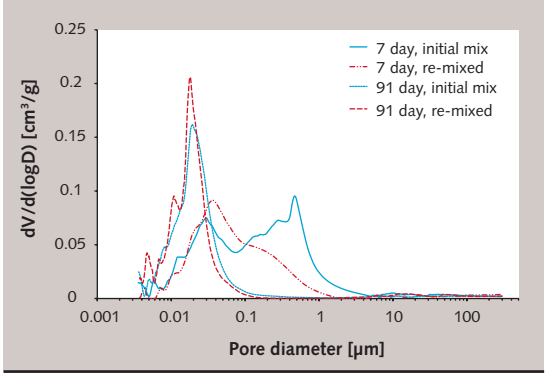
5 Effect of deactivation water (30 min storage) on compressive strength of a DARC mortar

There does not appear to be a consistent trend between mortar composition and Water Absorption Coefficient and Water Vapour Permeability for all binder types after four weeks curing. The WAC is higher than the value of 4 kg/m²/hr$^{0.5}$ considered critical for renders; the typical range may be 4–10 kg/m²/hr$^{0.5}$. This range compares to 2 kg/m²/hr$^{0.5}$ for Portland cement mortars and 14 kg/m²/hr$^{0.5}$ for an NHL 5 mortar. The range of values of WVP is 7–16 x 10^{-12} kg/m²/Pa/s. This range compares to 6 x 10^{-12} kg/m²/Pa/s for Portland cement mortars and 15 x 10^{-12} kg/m²/Pa/s for an NHL 5 mortar.

Associated with the transport properties is the porosity which in the case of the Roman cement mortars lies in the range 18–22 % with NHL 5 being higher at 23 % and Portland cement much lower at 11 %.



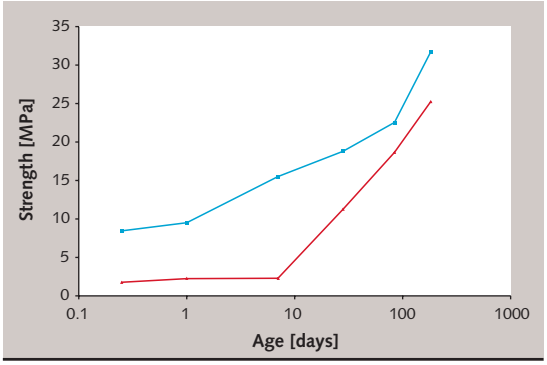
6 Workability of a re-mixed render mortar

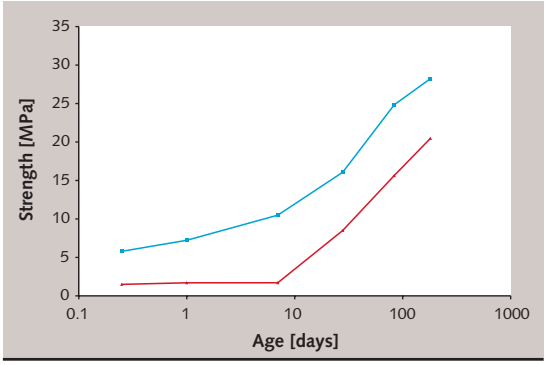


7 Influence of re-mixing process on pore structure

8 Strength envelope for 1:0.5 mortars (left)

9 Strength envelope for 1:1 mortars





3.3 Hybrid Render mortars

During the study of historical mortars [1] it was observed that render mortars often contained lime. Whilst contemporary handbooks [10–12] contain details of mortar formulations for various purposes no specification has been found for the inclusion of lime, e.g. lime type, cement/lime proportions or property development. It has been shown that the addition of lime in the form of both CL90 and NHL 5 does not increase the workable life of hybrid mortars [13]; consequently, retardation is essential. A study has been undertaken using both NHL 5 and CL90 as a partial replacement for Gartenau cement in a 1:1.5 render mortar. Two mix formulations were used in which the lime content formed 50 % and 67 % by volume of the binder phase.

It is apparent the inclusion of lime to create hybrid mortars affects the performance of a DARC mortar in both the fresh and hardened states. The hybrid mortars exhibit longer workable lives than the original mortar although neither the lime type nor replacement level are significant factors (Fig. 12). As expected, the use of lime decreases the mortar strength with 50 % NHL 5 > 50 % CL90 > 67 % NHL 5 > 67 % CL90 (Fig. 13). The hybrid mortars possess higher values of water absorption coefficient such that it is possible to double the WAC in comparison to the original DARC mortar (Fig. 14).

Further details on pore structure, shrinkage and the influence of curing regime on mortar properties are available elsewhere [13]. Shrinkage cracking is a characteristic feature of many historic Roman cement constructions. The susceptibility of such mortars to cracking has been comprehensively reported by Wilk et al. [14,15].

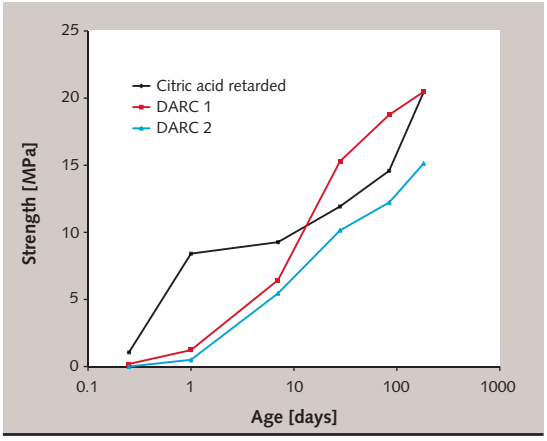
The appropriate use of lime permits the refinement of mortar properties to achieve specified properties. If NHL is to be used then it is recommended that trials are conducted since they vary in performance just as do Roman cements since they reflect the characteristics of the limestone from which they were calcined.

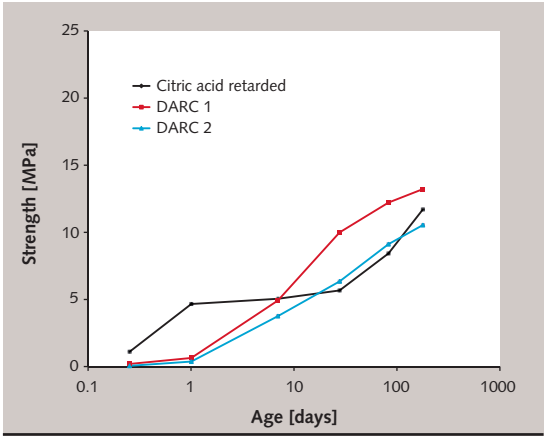
4 Conclusions

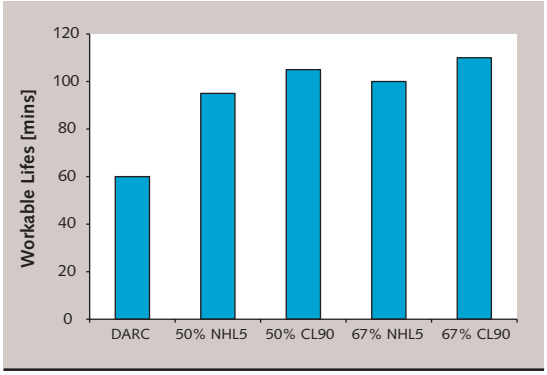
The results of mortar testing clearly show that Roman cement produces mortars with properties different to those yielded by the use of either Portland cement or Natural Hydraulic Lime. The water transport properties are higher than those commonly required for restoration materials indicating a good basis for compatibility with existing products. Retardation is a key factor and a “de-activation process” is likely to give the best results for render mortars requiring a substantial workable life. This technique is not appropriate for mortars for cast elements since the early age strength is low and

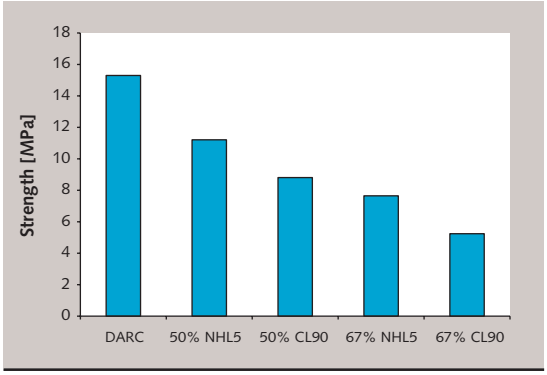
10 Strength for 1:1.5 mortars (left)

11 Strength for 1:2.5 mortars





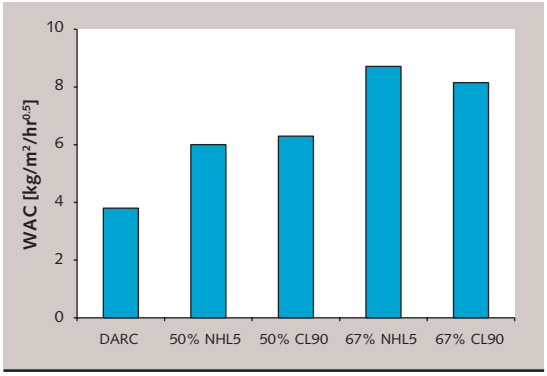




12 Workable life of hybrid mortars (left)

13 Strength of hybrid mortars

would prevent rapid demoulding. The use of lime to yield hybrid mortars permits the fine tuning of mortar performance across a range of properties.



14 WAC of hybrid mortars

5 Acknowledgements

The authors would like to express their appreciation of the support provided by the EU and the contributions of many colleagues from the ROCEM (Contract EVK4-CT-2002-00084) and ROCARE (Call identifier FP7-ENV-2008-1, Project number 226898) projects, particularly Brigitte Pestitschek and Blanka Kolinkeova.

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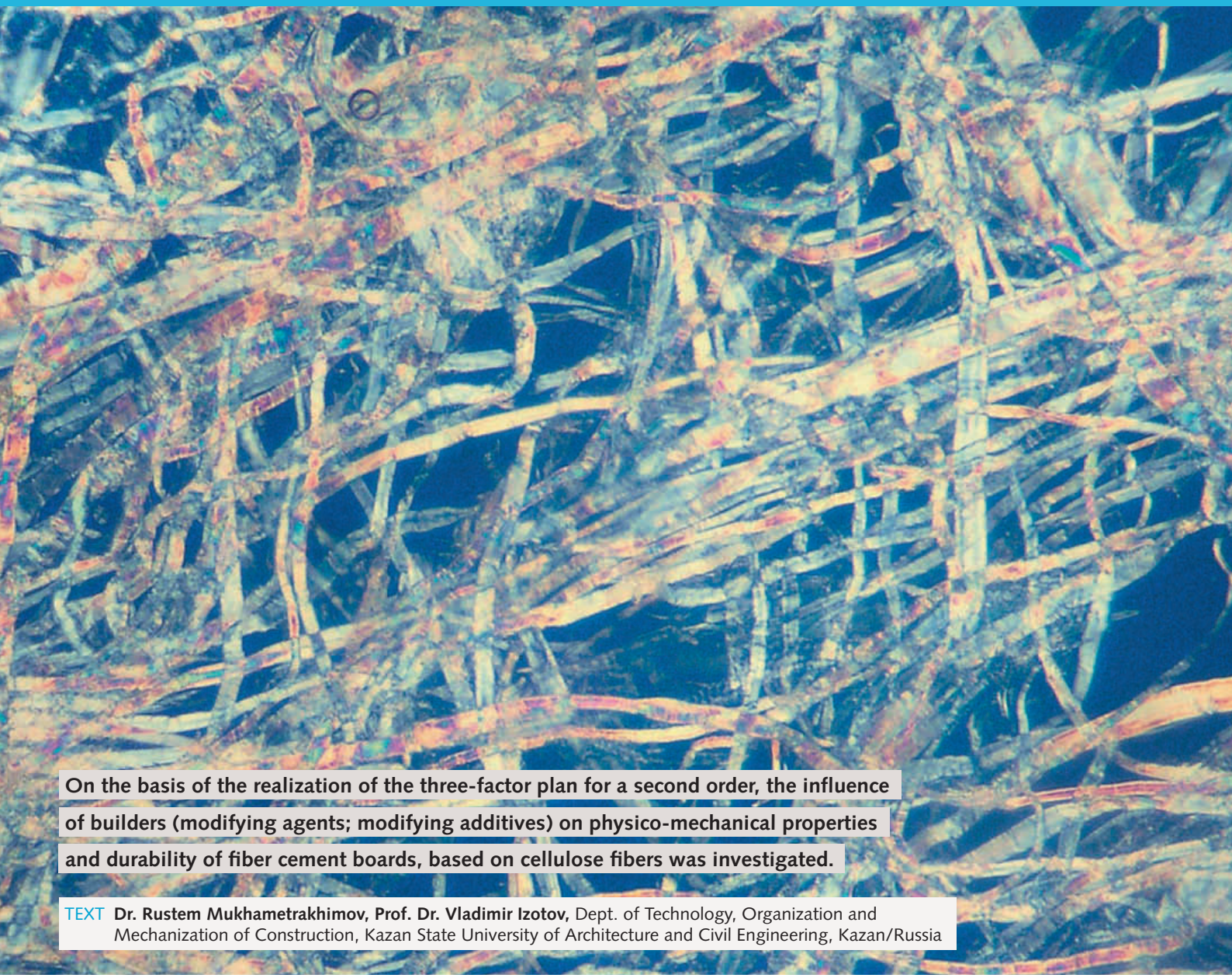


On the basis of the realization of the three-factor plan for a second order, the influence of builders (modifying agents; modifying additives) on physico-mechanical properties and durability of fiber cement boards, based on cellulose fibers was investigated.

TEXT **Dr. Rustem Mukhametrakhimov, Prof. Dr. Vladimir Izotov,** Dept. of Technology, Organization and Mechanization of Construction, Kazan State University of Architecture and Civil Engineering, Kazan/Russia

Cellulose under the microscope (magnified 200 times, with polarization filters)

KAZAN UNIVERSITY OF ARCHITECTURE AND CIVIL ENGINEERING

Experimental research to improve the performance properties of fiber-cement slabs based on cellulose fibers

1 Introduction

At present, a large proportion of buildings that have long life, do not meet modern thermo-technical and aesthetic requirements. For decoration facades of newly constructed and renovated buildings with insulation, ventilated facade systems are used that allow restoring the old facades by giving them a more modern look. As covering material, these systems use a variety of different materials like granite, aluminum panels, polymeric materials, fiber cement board (FCB), etc. However, most of them are imported from other countries and repre-

sent a high value. Because of this and their fragility, they can't always be used for buildings in harsh weather conditions like in Russia.

The most widespread and available facing material on the domestic Russian market are fiber cement panels, based on asbestos fibers. Due to the meanwhile proven carcinogenicity of asbestos, the demand for these products is decreasing year by year to almost zero. In this connection, it becomes urgent to develop a new effective facing material made from environmentally save and pure raw material of low cost, capable of ensuring reliability, durability and energy efficiency in buildings. In addition this raw material has to offer the possibility to be processed on the production lines of asbestos-cement boards with the maximum use of any existing equipment. FCB on the basis of cellulose fibers instead of asbestos fibers might be the right way, as the production process is similar to asbestos-cement boards.

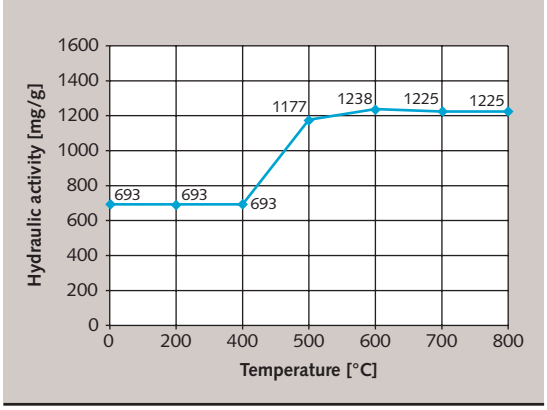
The disadvantages of the existing FCB based on cellulosic fibers include low strength, high water absorption and low resistance to frost. These problems require urgent work to develop issues of quality and durability of FCB based on cellulose fibers.

In our previous investigations [1] we investigated the effect of the matrix (for cement: sand) with varying degrees of dispersion of silica sand and an alternating coefficient of fiber reinforcement plus the grinding of the cellulose fibers on the physico-mechanical characteristics of the FCB. We also investigated the effect of a number of active mineral additives (AMA), characterized by their mineralogical composition and hydraulic activity, the influence of some organic silicon compounds, plus the addition of polyacrylamide on the kinetics of hydration of mixed binders and the physical-mechanical properties of the produced FCB [2, 3, 4].

2 Recent research

This work presents the results of our experiments to improve the hydraulic activity of kaolin as well as the physical and mechanical properties and durability of FCB, based on cellulose fibers produced with the wet method. The materials used were AMA (activated kaolin and organosilicon compound OSC), "FES-50" manufactured by Khimprom, Novocheboksarsk and polyacrylamide (PCA) "Besfloc K4046" from Kolon Life Science, Inc., South Korea.

The hydraulic activity of kaolin is increased by heating up and subsequent acid activation. We found that the thermal treatment of kaolin increases its hydraulic activity with 693–1238 mg/g, while the optimum temperature of heat treatment lies around 600°C with a processing time of 30 min (Fig. 1). The

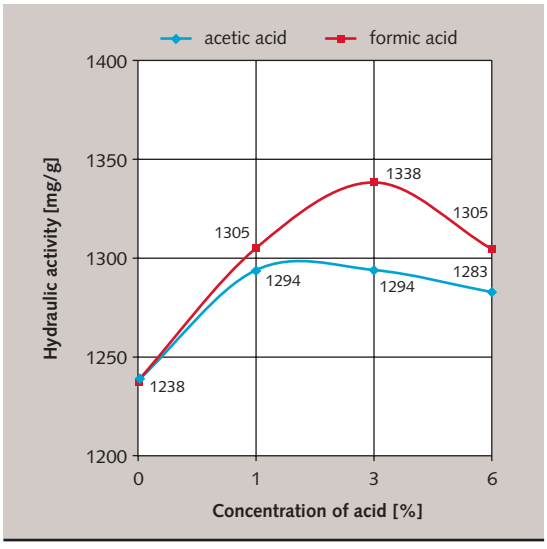


1 Effect of firing temperature of kaolin on its hydraulic activity

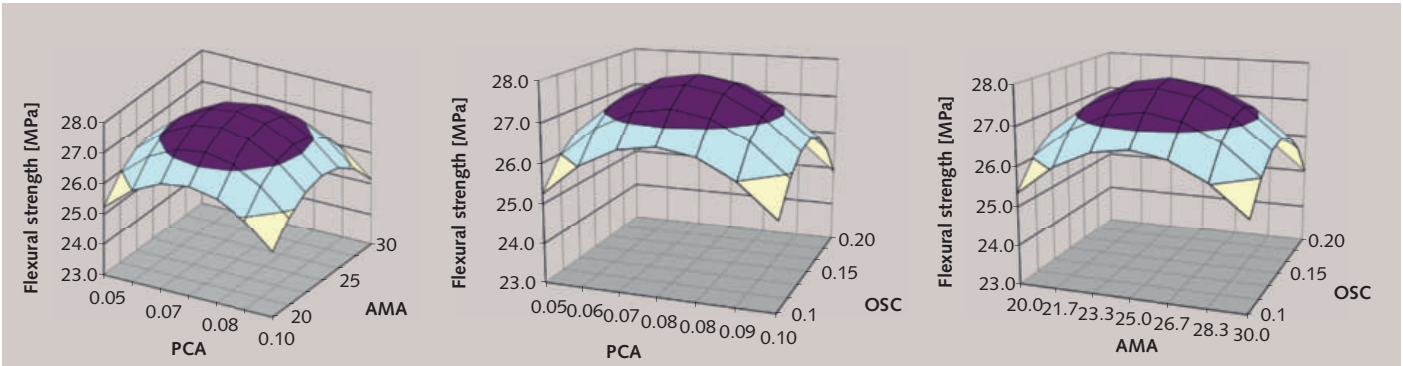
subsequent activation of metakaolin with a formic acid solution of 3 % doubles the hydraulic activity compared with the original kaolin (Fig. 2).

Features on the effect of thermal and acid treatment of kaolin to change its phase composition were examined by IR spectroscopy. Investigations on metakaolin activated by a formic acid solution of 3 % (hereinafter referred to as metakaolin-A) showed a sharp intensity increase of the wave bands in the range of wave numbers 3600–2900 cm^{-1}, corresponding to the stretching vibrations of associated OH groups, and in the 1651–1644 cm^{-1} wave area.

On the other hand, the relative intensity of the peaks in the frequency ranges 913–912 and 1032–1029 cm^{-1}, which are responsible for the perturbation of oxygen-containing groups Si-O and the bond in the octahedral layers of Al_3 + O_2-and OH-, decreases with the factor 1.6 to 2.3. Of particular interest is the IR spectra appearance of the metakaolin-A peak in the region 2146–2144 cm^{-1}, which is quite possibly related to the formation in the communication system Si-H. Characteristically, with increasing concentration of formic acid in the system with 1–3 wt.%. The intensity of this absorption band



2 Effect of acid activation on the hydraulic activity of metakaolin



3 Effect of the form and content of the modifying additives on the flexural strength of FCB

is doubled, which is probably due to the partial destruction of the aluminosilicate under the action of formic acid. Presumably, the formation of the solvation shell on the surface of the solid phase increases significantly the number of bound OH groups, as well as the possible formation of Si-H-bonds. Thus, treatment of metakaolin formic acid can increase the number of associated OH-groups. And probably, it can lead to the formation of Si-H-connections.

The next step of research carried out the optimization of the federal program of increased longevity on the basis of a modified mixed binder, through a three-factor second-order plan. The initial independent variables are defined by factors such as content: PCA (X_1), AMA – metakaolin-A (X_2), OSC (X_3) in percent by weight of cement as a response of selected flexural strength of FCB (R), water absorption (W) and frost resistance (F).

Processing of the results of mathematical planning has provided the following mathematical relationship:

$$R = -43.135 + 326.4\,X_1 + 3.13X_2 + 162.53X_3 + 0.35\,X_1X_2 - 2252.9\,X_1^2 - 0.053\,X_2^2 - 550.86\,X_3^2 \quad (1)$$

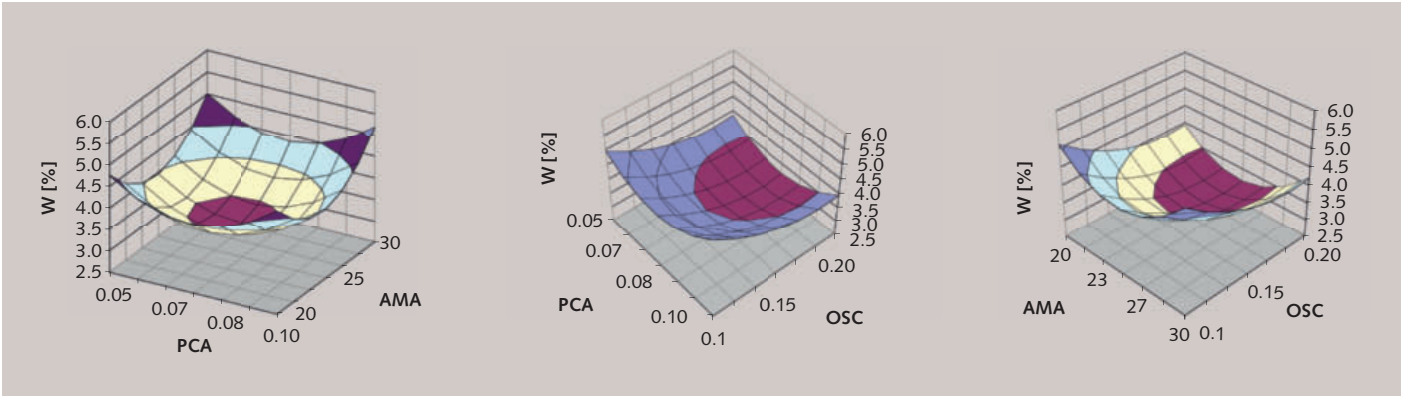
$$W = 37.44 - 171.98\,X_1 - 1.82\,X_2 - 60.73\,X_3 + 0.095\,X_1X_2 - 28.57\,X_1X_3 - 0.0476X_2X_3 + 1180.21\,X_1^2 + 0.0369\,X_2^2 + 174.1\,X_3^2 \quad (2)$$

$$F = -1757.5 + 13485.9\,X_1 + 97.58\,X_2 + 3476.64\,X_3 - 91506\,X_1^2 - 1.952\,X_2^2 - 9436.4\,X_3^2 \quad (3)$$

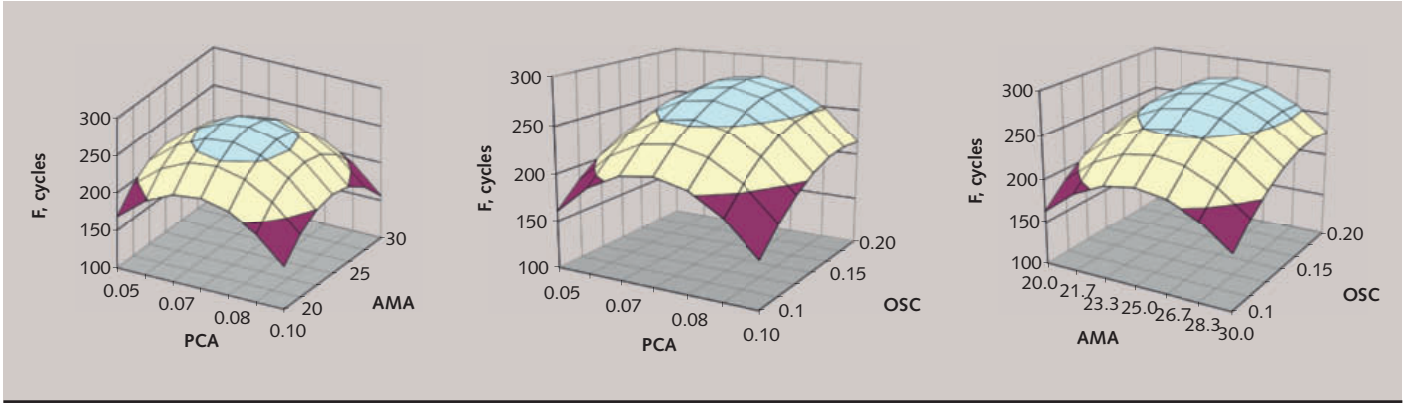
To determine the adequacy of the obtained regression equations, we assessed their statistical significance with the tabulated value (Fisher test). Figures 3-5 show a graphical interpretation of the results of the mathematical models' processing.

As follows from the regression equation (1) and the data shown in Fig. 3, with increasing costs of AMA and PAA in the fiber-cement mixtures an increase in the strength of the FCB. Joint increasing doses of PCA plus AMA, and AMA plus OSC first leads to a gradual increase in strength, and afterwards to a reduction. The decrease in strength of FCB with increasing doses of PCA and OSC is apparently due to a blocking action on the particles of Portland cement additive molecules, which is especially clearly manifested in their joint introduction.

The water absorption (mathematical dependence 2 and Fig. 4) of FCB decreases with increasing doses of OSC and increases with increasing doses of co-PCA and AMA. The increase in frost resistance occurs at a higher dose of AMA, as well as the combined action of increased additives AMA and OSC, as the mathematical dependence (3) and Figure 5 point out. In Figure 3 it is visible that the optimum content of modifying agents markedly affects the



4 Effect of the form and content of the modifying additives on the water absorption of FCBB



5 Effect of the form and content of the modifying additives on the hardiness of FCB

strength of the FCB. Thus, on the basis of mathematical experiment planning, the optimal dosage of the active mineral and chemical additives in the fiber-cement mixtures is:

» PCA 0.075%, AMA 25%, OSC 0.15%, respectively to the cement weight.

Further research was carried out taking into account the optimal content of modifying additives in the fiber-cement mixture. On the basis of the mathematical experiment planning we determined the optimum content of the mixed components of the modified binder for FCB increased durability.

Results of the study phase of fiber-cement matrix based on a modified mixed binder showed that in general there is a substantial increase in the number of hydro C_2SH (C) with an interplanar distance of 2,77 Å, lowly basic hydro-type calcium CSH (A) (2.74 Å) and tobermorit (2.97 Å) as well as lower peak values of $Ca(OH)_2$ and highly basic types of hydro C_2SH_2 (2,18 Å). Reducing the peaks of calcium hydroxide due to its binding to the AMA means low basic hydrosilicates type calcium CSH.

Samples of the fiber-cement matrix using differential thermal analysis showed that on the basis of the mixed modified binder these are able to form a deeper hydration of the silicate phase, as evidenced by an increase in endoeffect at 160–170 °C. IR spectroscopy of the cement confirms the results RPA and DTA.

Samples of FCB of increased durability were tested for shrinkage deformation/swelling resistance of the air and thermal conductivity.

The obtained FCB had the following specific characteristics:

» flexural strength: 27.5 MPa
» thermal conductivity: 0.22 W/m°C
» shrinkage: 0.2 mm/m
» freeze-thaw cycles: 250 cycles
» resistance of the air: 300 cycles
» impact strength: 2.5 kJ/m²

3 Conclusions

The results of the studies suggest the following conclusions:

» It has been established that the increase of hydraulic activity kaolin 693–1338 mg/g ensured by thermochemical activation consisting in the preliminary heat treatment at a temperature of 600°C and the subsequent activation of the acid in a solution of formic acid.
» On the basis of the mathematical planning of the experiment, the optimal dosage of modifying additives composed fiber cement mixture enhanced durability: PAA – 0.075%, AMA – 25%, OSC – 0.15% by weight of cement.
» The increase of physical and mechanical properties and the increase of durability of the fiber cement matrix due to the formation of optimal microstructure of cement stone, contain high amounts of calcium hydro, mainly lowly basic type.

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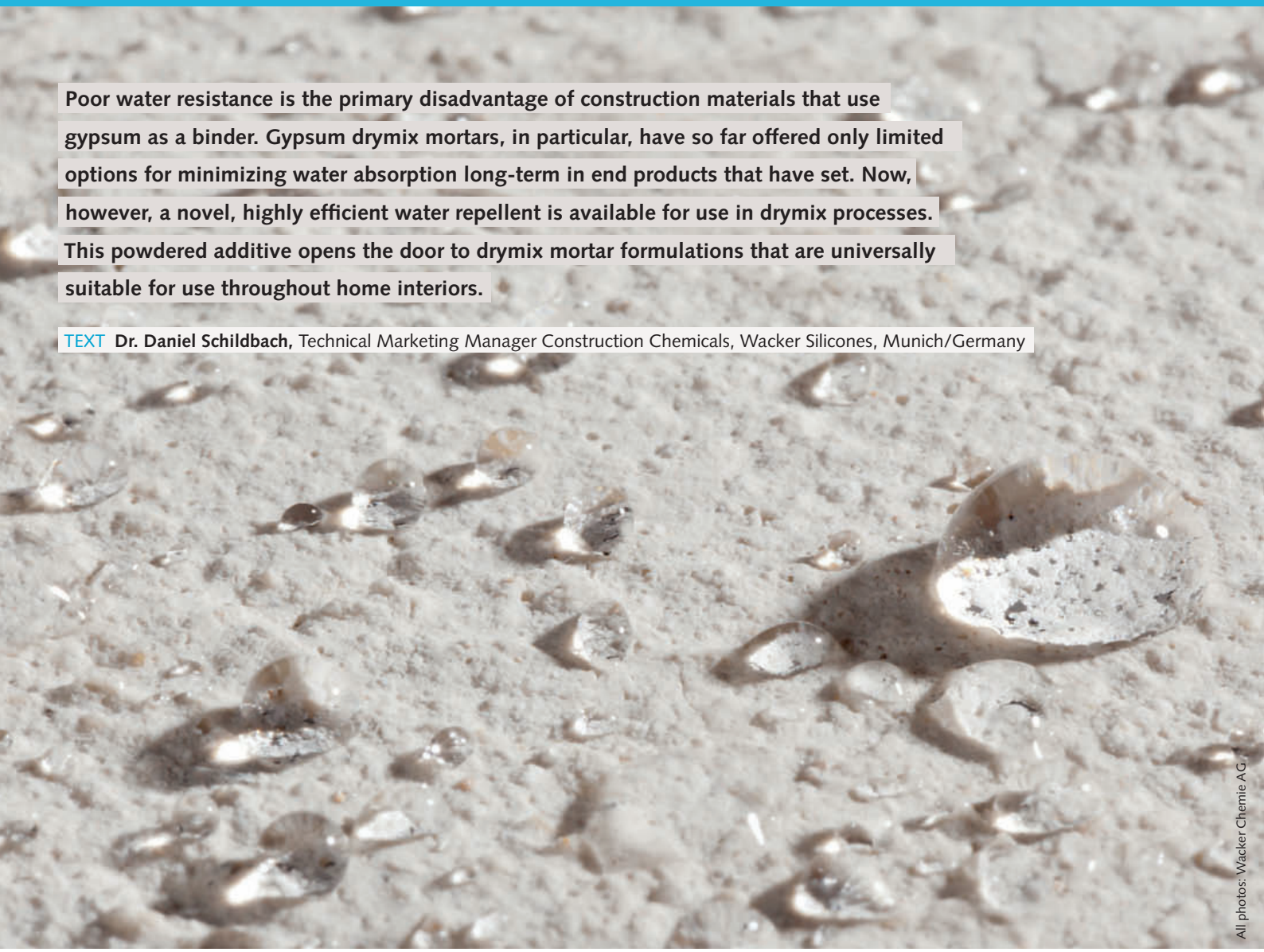


All photos: Wacker Chemie AG

Poor water resistance is the primary disadvantage of construction materials that use gypsum as a binder. Gypsum drymix mortars, in particular, have so far offered only limited options for minimizing water absorption long-term in end products that have set. Now, however, a novel, highly efficient water repellent is available for use in drymix processes. This powdered additive opens the door to drymix mortar formulations that are universally suitable for use throughout home interiors.

TEXT **Dr. Daniel Schildbach,** Technical Marketing Manager Construction Chemicals, Wacker Silicones, Munich/Germany

Gypsum drymix mortars formulated with SILRES® BS Powder S are water repellent, making them suitable for universal use in interior applications

WACKER SILICONES

A new water-repellent agent for gypsum-based drymix mortars

1 Introduction

Builders appreciate gypsum-based construction materials for more than just economic and environmental reasons – they also value their favorable processing characteristics, as well as the physical and biological properties they exhibit in construction applications. These materials, for instance – especially plasters that use gypsum as a binder – create a comfortable indoor climate, because they regulate interior humidity and always feel pleasantly warm and dry to the touch.

Set gypsum has two weaknesses that limit its potential applications, however: it has relatively poor hardness, and is slightly – yet noticeably – soluble in water (the solubility of calcium sulfate dihydrate is roughly 2.6 g/L at 20°C). Gypsum-based construction materials lose their compressive strength when saturated with moisture, and

relatively long exposure to water or repeated exposure to fresh water irreversibly damages their structure. While their sensitivity to water is the primary concern, their low hardness also makes gypsum-based construction materials generally unsuitable for exterior applications in most climates.

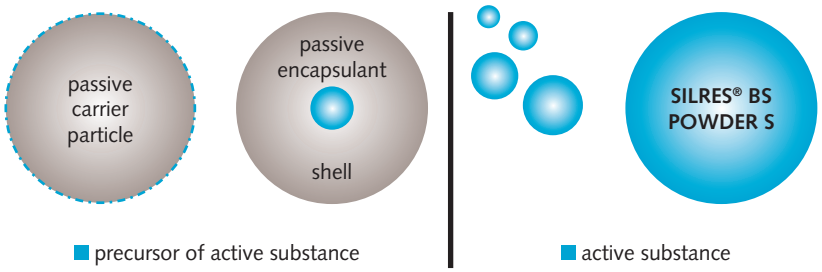
Indeed their water sensitivity even limits the uses of gypsum-based construction materials in interior applications. Gypsum-based construction materials should only be used in damp rooms, if they have been made effectively hydrophobic, i.e., water repellent. Hydrophobicity is difficult to achieve in gypsum-based drymix mortars, as the powder water repellents that have been available up to now only meet the requirements of gypsum construction material manufacturers in isolated cases.

The Munich-based Wacker Group has now developed a completely new powdered water repellent for gypsum-based materials. Commercially available under the name SILRES® BS Powder S (patent pending), the new product was introduced first in October 2012. The additive has been designed for use in the drymix process and allows manufacturers to produce gypsum-based wall plasters, joint fillers, top coat materials, flooring screeds and adhesives that can be used throughout the interior of a building.

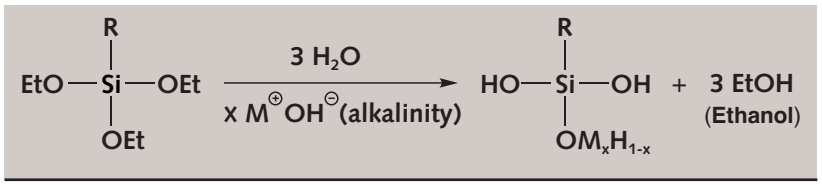
2 Traditional water repellents

Additives for making gypsum construction materials water repellent have been around for some time. Organosilicon water repellents based either on what are known as H-siloxanes (polymethyl hydrogen siloxanes) or on alkali alkyl siliconates have proven highly effective for gypsum building panels, such as gypsum plasterboard, fiberboard or block. Additives in the first group are applied as either oils or as aqueous emulsions; the latter are applied as aqueous solutions. All of these materials, in other words, are liquids and, as such, are not suitable for use as additives when formulating drymix mortars.

In order to obtain free-flowing, solid additives from available liquid agents, silicone manufacturers and formulators have had to make use of a trick: they take the active agent, which is itself a liquid, and either encapsulate it within a solid material or adsorb it on a solid carrier material, thereby creating a vehicle for introducing and blending the agent into the drymix mortar formulation (Fig. 1, left). In practice, silicone manufacturers do not even actually use the active agent itself (an alkyl silicic acid), but rather a liquid precursor of the active agent, such as an alkyl silicic ester, a polyalkyl silicic ester or mixtures of these (also known as alkylalkoxysilanes and alkylalkoxysiloxanes). They do this because the actual active agent is highly reactive, ruling out the option of isolating it and using it directly.



1 Traditional powdered gypsum water repellents (left and center) are available in carrier or encapsulation systems. SILRES (right), however, is a completely new, powdered water repellent in which the active agent itself is used



2 In traditional powdered gypsum water repellents, the actual active agent – an alkyl silicic acid – is formed in situ via alkaline hydrolysis of an alkyl alkoxysilane. M stands for an alkali metal or alkaline earth metal. The monomeric structure of the alkyl silicic acid (and/or alkyl siliconate if the pH is elevated) shown here on the right-hand side of the equation is only an example, further structures could be formed as well

This also rules out encapsulating the liquid organosilicon water repellents that have been used in large-scale applications up to now, just as it rules out depositing them onto a carrier. H-siloxanes, for instance, react with protogenic compounds by evolving hydrogen – consequently it is risk to process H-siloxanes in spray-drying systems. Siliconates prevent stable encapsulation, because the encapsulation material (usually polyvinyl acetate) would saponify, and the siliconates could react with the surface of the carrier material and be immobilized. The only remaining option that silicone manufacturers had for obtaining a free-flowing, solid gypsum water repellent was to fall back on available liquid precursors and "package" them suitably.

When gypsum drymix mortars that include this kind of carrier-based or encapsulated active agent are mixed with water, the liquid substance leaves its "packaging" and is converted to the actual active agent (an alkyl or polyalkyl silicic acid) via hydrolysis (Fig. 2). There are numerous disadvantages associated with the use of these traditional solid water repellents, however:

» First of all, the solid additive contains very little active substance, because the carrier and/or encapsulating material can only accommodate

Water absorption (according to EN 520)	< 5 %
Amount used	< 0.5 %
Mixing characteristics (mixing the drymix mortar with water)	Excellent
Dust formation (mixing the drymix mortar with water)	None
VOC release	None

Table 1 Requirements stipulated by manufacturers of gypsum construction materials for water repellents used in gypsum drymix mortars

around 30 % of the precursor. Loading these materials with larger amounts of liquid yields a sticky additive that is no longer free flowing. Because the carrier and/or encapsulating material itself has no effect whatsoever, at least 70 % of the bulk of the additive contributes nothing toward making the mortar water repellent. This, in turn, means that large quantities must be used, which is why traditional solid water repellents are so inefficient.

» Second, mixing the gypsum drymix mortar with water results in hydrolysis, and, if this reaction is to proceed at a practical rate, the mortar has to be rendered highly alkaline. If the pH of the blended compound is too low, the gypsum will set faster than the precursor can hydrolyze and be converted to the agent itself, thus rendering the additive largely – or entirely – ineffective. Yet, even if the pH is sufficiently high, the chemical reaction does take some time to proceed. Water repellency, in other words, would not take effect in the set gypsum plaster material for some time.

» Third, traditional solid water repellents release volatile organic compounds (VOCs) when applied, because the alkoxy groups of the precursor compounds dissociate as alcohols during alkaline hydrolysis. Today, however, VOCs should be avoided for health reasons, especially in interior applications.

» Fourth, traditional solid water repellents cause mixing problems. Once gypsum drymix mortars have been packaged, the liquid components of the additives can migrate from carrier materials and/or from the encapsulation material onto the surrounding bulk solid and the calcium sulfate hemihydrate or anhydrite. This can even occur while the materials are still in storage, thus making the binders and fillers water repellent before the mixing water is added. As a result of these unfavourable wetting properties, the mortar takes a long time to mix with water and develops a significant amount of dust, because the mixing water cannot wet the hydrophobic plaster dust. This should also be avoided, not least for health reasons.

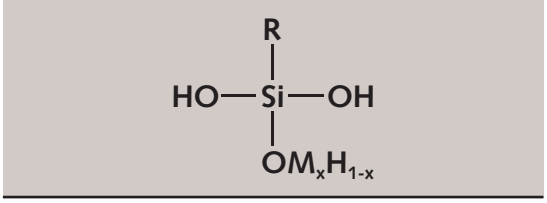
Manufacturers of gypsum construction materials have been looking for a water repellent that would be suitable for use in drymix processes, would be exceptionally efficient, pose no problems when mixed with water, and would not release any VOCs when used (Table 1). Regarding water repellency, a few manufacturers of gypsum construction materials indicated that an ideal additive would reduce water absorption to below 5 percent by weight (after being stored under water for two hours, as described in EN 520). These manufacturers anticipate that absorption below this level would allow them to make universal dry mixes for use in any interior applications.

3 A new solution

SILRES® BS Powder S circumvents all of the problems that arise with traditional solid gypsum water repellents. This new water repellent consists of the pure active agent itself (Fig. 1, right) and, most importantly, contains no carrier or encapsulation materials, making it highly efficient. The development of this product represents a substantial breakthrough: the active agent is a potassium methyl siliconate (Fig. 3), a colorless, odorless, free-flowing powder produced via a special process that is environmentally friendly and conserves resources. The x variable in the structural formula indicates that the composition of the substance, and therefore its properties, can be adjusted. Potassium methyl siliconates have been used for protecting masonry since the 1950s, serving such purposes as imparting water repellency to the surfaces of heavy clay products or to the materials used in prefabricated gypsum building elements. Up to now, however, alkali alkyl siliconates – as indicated earlier – have only been produced and used in the form of aqueous solutions.

Wacker has now devised a large-scale method for obtaining alkali alkyl siliconates as free-flowing solids. The Munich-based group of companies has developed a variety of drying processes for making powders with different properties. The potassium-silicon ratio has also been adjusted to optimize the balance between stability, reactivity and pH in gypsum-based construction materials.

Because potassium methyl siliconates already contain the silica groups necessary for the inter-



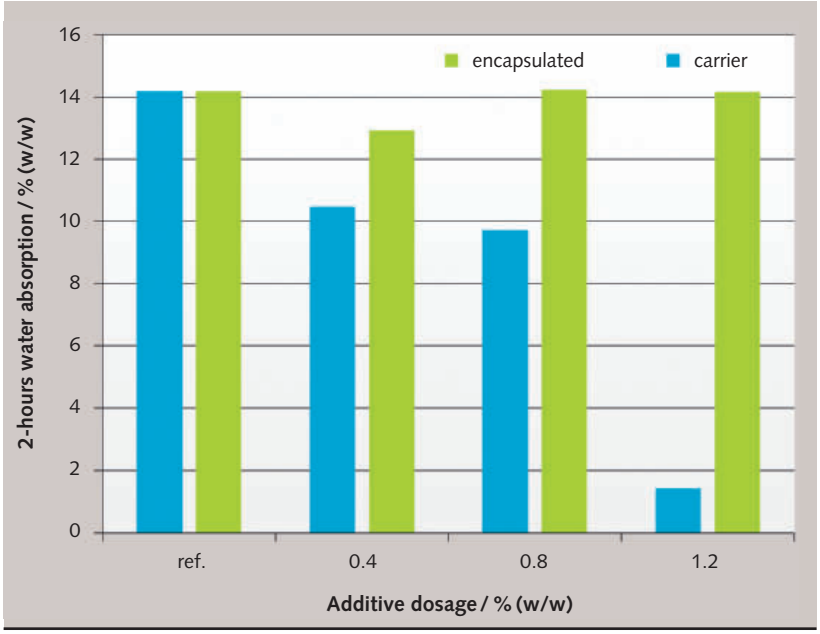
3 The structure of the potassium methyl siliconate in the new SILRES, M symbolizing potassium. The potassium-silicon ratio can be adjusted and optimized with respect to the additive's interaction with gypsum crystals by varying parameter x

action with gypsum, there is no need for a preliminary chemical reaction to generate these groups. The siliconate itself is already in its effective form, which means that, unlike traditional water repellents, the new product eliminates the need for elevating the pH of the material formulation in order to induce alkaline activation. The product also produces no VOCs. The active agent itself is astonishingly hydrophilic and water-soluble, resulting in outstanding mixing behavior. When stirred into water, gypsum drymix mortars modified with this additive mix very quickly without forming any dust.

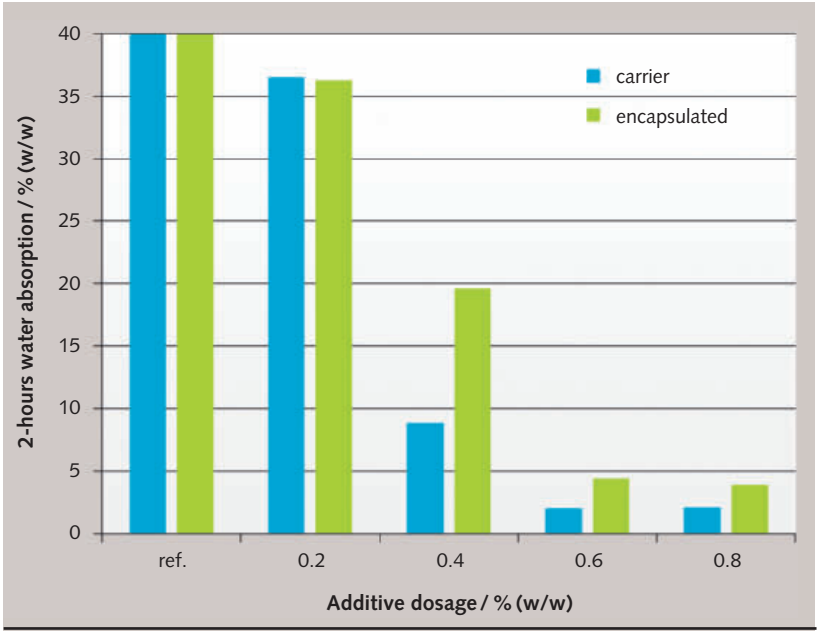
When the calcium sulfate hemihydrate is blended with the mixing water, the water soluble potassium methyl siliconate goes into solution very quickly. While the plaster sets, the siliconate selectively interacts with the growing gypsum crystals, using its hydrophilic silica groups to anchor itself onto the gypsum crystal surfaces. Its hydrophobic methyl groups, however, point away from the crystal surfaces of the calcium sulfate dihydrate being formed. This orientation causes the siliconate to lose its original hydrophilic properties and form a shield that prevents water from penetrating the gypsum crystals in the set material. When applied in this way, the potassium methyl siliconate makes the material hydrophobic throughout, as evidenced by the tendency of water to bead in cracks on plaster objects in which the additive has been used. In other words, the mechanism of action utilizes the balance between the hydrophilic properties of the active agent before it is anchored in place and the hydrophobic properties of the active agent after it has adsorbed to the gypsum crystals.

The interaction between the siliconate and the gypsum is primarily electrostatic in nature, which is an interaction between ions, i.e., charged particles, either with each other or with polar OH^- groups. As the gypsum sets, a monomolecular layer of the active agent is formed on the faces of the growing gypsum crystals, making the capillary surfaces within the structure of the construction material hydrophobic, yet without sealing them off. This means that the outstanding permeability of gypsum construction materials to water vapor remains unaffected.

SILRES® BS Powder S is suitable as an additive for an exceptionally wide variety of gypsum-based drymix mortars and can be used at any pH relevant for practical applications. Because this additive is the active agent itself and not a precursor, its properties take effect with no delay, immediately after the plaster material sets – and not after a preliminary reaction time has elapsed.



4 The effect of traditional, commercially available water repellents in a gypsum-based joint filler (pH 9, water-to-solid factor = 0.50)



5 The effect of traditional, commercially available water repellents in a lime-gypsum plaster for machine application (pH 12, water-to-solid factor = 0.60)

4 Testing efficacy and efficiency

The efficacy of the new powdered additive was tested as directed in EN 520, using test objects made of many different kinds of gypsum-based drymix mortars. The test objects were prepared as described in EN 196-1, while varying the amount of water repellent used. A formulation with no water repellent (amount used = 0 %) served as a reference for each. The following gypsum drymix mortar formulations were studied: a joint filler (pH 9, water-to-solid factor: 0.50), a hand-applied lime-gypsum plaster (pH 12, water-to-solid factor: 0.67), a machine-applied lime-gypsum plaster (pH 12, water-to-solid factor: 0.60), a machine-applied lime-gypsum plaster with a high content of filler (70 % carbonates, pH 12, water-to-solid factor: 0.35) and a flooring screed (pH 11, water-to-solid factor: 0.17). Traditional solid water repellents were tested for comparison.

The studies began with a comparison between two traditional, commercially available powdered gypsum water repellents. Each of these products was based on a precursor to the active agent – one carrier-based and the other encapsulated. Comparison studies confirmed that high concentrations of the traditional water repellents had to be used and that the additives either worked poorly in many drymix mortar formulations or not at all.

As described earlier and as expected, the pH of the gypsum substrate has a major impact on efficacy. This is because the actual active agent has to be generated in situ via alkaline hydrolysis. As such, the encapsulation system is completely ineffective in a joint filler with a pH of 9 (Fig. 4), as the hydrolysis reaction clearly proceeds too slowly at this pH to release enough silica groups. The poor efficiency of traditional additives is also evidenced in lime-gypsum plasters for manual applications (Fig. 5): despite the high pH of 12, satisfactory results depend on a high concentration of water repellent.

Drymix mortar formulations modified with SILRES® BS Powder S behaved very differently, however (Figs. 6, 7 and 8). The water absorption measured as a function of additive dosage shows that the new water repellent is highly effective and highly efficient – in all gypsum drymix mortar systems and at any pH that typically arises in gypsum-based formulations. Large amounts of filler in the drymix mortar formulation do not increase the values measured for water absorption. As shown in Fig. 6, an additive concentration of just 0.1 % lowers water absorption to below the limit required by the gypsum industry (Tab. 1) for a gypsum joint filler with a pH of 9. When 0.2 % of the new additive is used, the set joint filler absorbs 95 % less water than the reference system after two hours of immersion in water. Increasing the amount used to over 0.2 % does not reduce water absorption any further.

This is also true when organosilicon water repellents are used in other gypsum based construction materials, where a point is likewise reached at which increasing concentration does not further increase the desired hydrophobic effects (Figs. 7 and 8). While this limit depends on the system, it generally lies below 0.3 %. For most

gypsum-based drymortar formulations, an additive concentration of around 0.2 % is enough to lower water absorption values to below 5 %. Figures 6 and 8 also show how SILRES® BS Powder S selectively deposits onto the gypsum crystals and not onto the filler granules – otherwise the large surface area of the fillers would, in both cases, require significantly more than 0.2 % to achieve the desired water repellency.

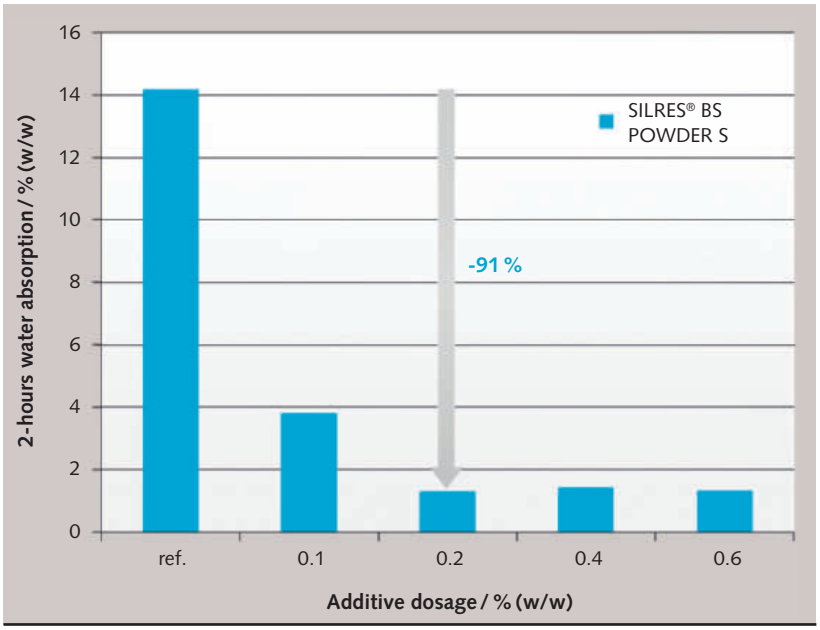
The new water repellent suppresses water penetration so effectively that it can keep water absorption to below 5 % even after seven days of immersion in water – given an appropriate concentration of additive. No other water repellent was able to achieve this, as evidenced by the exemplary study performed on gypsum plaster test objects (Fig. 9). The starting point for this study was a commercially available, untreated lime-gypsum plaster (reference), to which SILRES® BS Powder S had been added at various concentrations. This drymix mortar was also modified using a carrier system. For comparison, the study also included a commercially available water repellent plaster. In other words, unlike traditional solid water repellents, the new additive can be used in gypsum construction materials to keep water absorption very low over long periods of time.

Not only does SILRES® BS Powder S reduce water absorption – it also generally causes significant beading on the surface of the material. When a water droplet is applied, it initially remains on the surface and does not penetrate the gypsum material for several hours. For hand- or machine applied plasters, droplets take roughly 4 hours to soak in when the new additive is used at a concentration of 0.2 % (added in a drymix process).

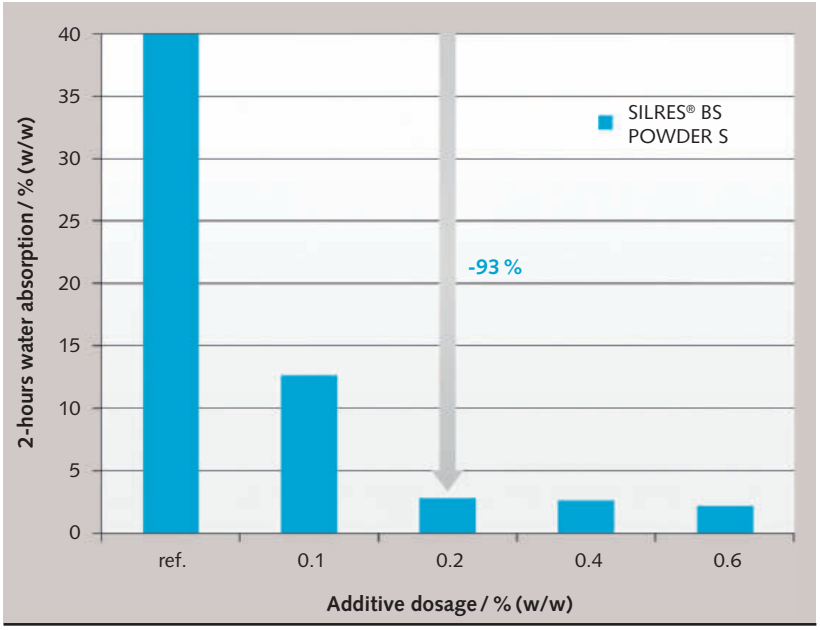
5 Side effects

As a highly effective water repellent, SILRES® BS Powder S can produce side effects under certain circumstances. For this reason, tests were performed to establish what properties other than water absorption are affected by the addition of water repellent and to determine the concentrations at which these side-effects occur. The studies revealed that SILRES® BS Powder S can affect the amount of air pores (determined as directed in EN 1015-7) in fresh mortars that have been combined with water. This effect is particularly pronounced in gypsum plasters for machine application, which contain more air entrainers than hand-applied plasters. When the additive is used at a concentration of 0.2 %, for instance, the amount of air pores diminishes slightly, which can be controlled by adjusting the formulation, i.e., by modifying either the concentration or the type of air entrainer.

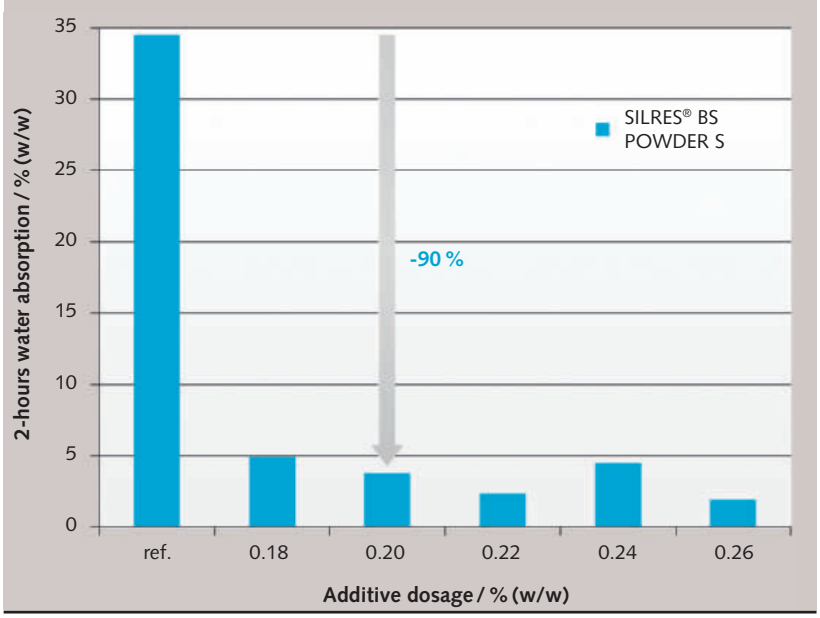
A sample study showed, however, that if the additive concentration is exceptionally high (0.5 %), the amount of air pores in machine-applied plasters fell by a good 60 % compared to a formulation to which no water repellent had been added. When this happens, the fresh mortar can no longer be processed correctly, as it becomes extremely thick under certain circumstances. In other words, there is therefore no reason to use more of this highly effective water repellent than recommended, and this should also be avoided for processing reasons.



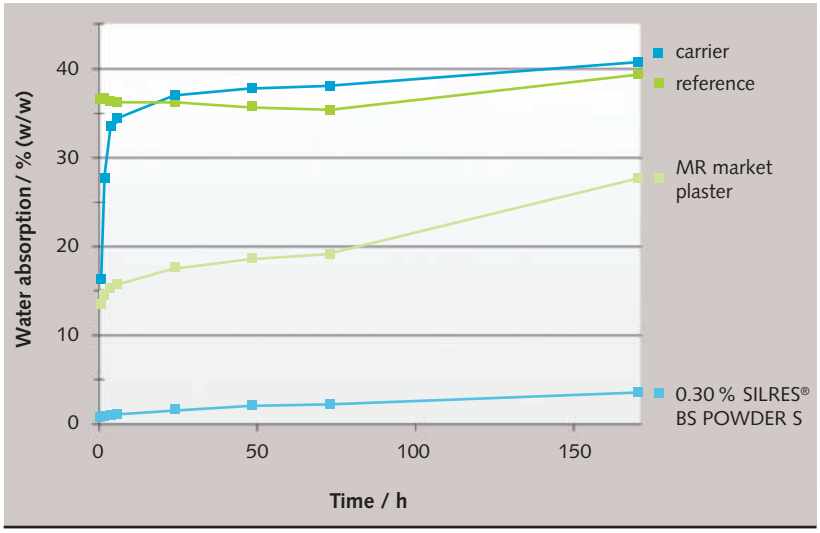
6 The effect of the new SILRES in a gypsum-based joint filler (pH 9, water-to-solid factor = 0.50)



7 The effect of the new SILRES in a lime-gypsum plaster for machine application (pH 12, water-to-solid factor = 0.60)



8 The effect of the new SILRES in a lime-gypsum plaster for machine application consisting of 30 % stucco and 70 % carbonate filler (pH 12, water-to-solid factor = 0.35)



9 Water absorption in test objects that had been immersed in water for long periods. The test objects consisted of gypsum plasters that had been modified with various water repellents. Addition of the new SILRES at a concentration of 0.3 % is enough to keep water absorption below 5 % in test objects immersed in water for seven days. MR stands for moisture-resistant

The sample study also showed that the additive affects the mechanical strength of the end products. Tensile, flexural and compressive strength all lie within the same range as the reference value at a relatively low additive concentration of 0.2 %. At higher concentrations, however, the deaeration process described above tends to increase strength in set mortars when compared to set formulations to which no water repellent has been added. While this side effect is positive in and of itself, it can be moderated, if needed, by adjusting the formulation.

When the new additive is used at the correct concentration, and any applicable side effects are offset by adjusting the formulation accordingly, then the fresh mortar can be applied to the substrate and worked as usual – workers do not notice any difference between it and untreated gypsum mortars. This has also been found to be the case for new formulations that manufacturers of gypsum-based construction materials have developed on the basis of SILRES® BS Powder S.

6 Conclusion

Thanks to SILRES® BS Powder S, the gypsum industry now has a highly efficient, powdered water repellent for gypsum-based drymix mortars. Even at very low concentrations, this new water repellent reduces capillary water uptake to such an extent that gypsum construction materials can even be used in damp locations, thereby solving the problem of poor water resistance in gypsum-based plasters, joint fillers, top-coat materials, flooring screeds and adhesives. Hydrophobicity takes effect as soon as the material has set, eliminating the need for alkaline activation. This additive provides the key to developing drymix mortars that are universally suitable for use throughout home interiors. Because there is now no technical reason for limiting the use of gypsum-based mortars to dry locations, manufacturers can now produce all-purpose plasters that can readily be used in home kitchens, bathrooms, stairwells and garages.

Gypsum-based drymix mortars modified with SILRES® BS Powder S could also theoretically be used in damp locations in commercial spaces. The new additive could even conceivably be used for exterior applications in certain regions of the world where the climate is relatively dry and where long periods of driving rain are unlikely – e.g., the Middle East or North Africa – as well regions where gypsum coatings are already used on exteriors.

Gypsum joint fillers and plasters containing SILRES® BS Powder S exhibit the same low water absorption properties over their entire surface areas. This characteristic can also be beneficial in terms of subsequent coats of paint, as it makes it possible to compensate for local differences in paint absorption due, for instance, to differences in the thickness of gypsum layers that arise when joint fillers are used for filling joints. The result is an even coat achieved with less paint. In summary, the new additive offers manufacturers of gypsum-based drymix mortars the opportunity to significantly expand their range of gypsum-based drymix mortars and open up new markets.

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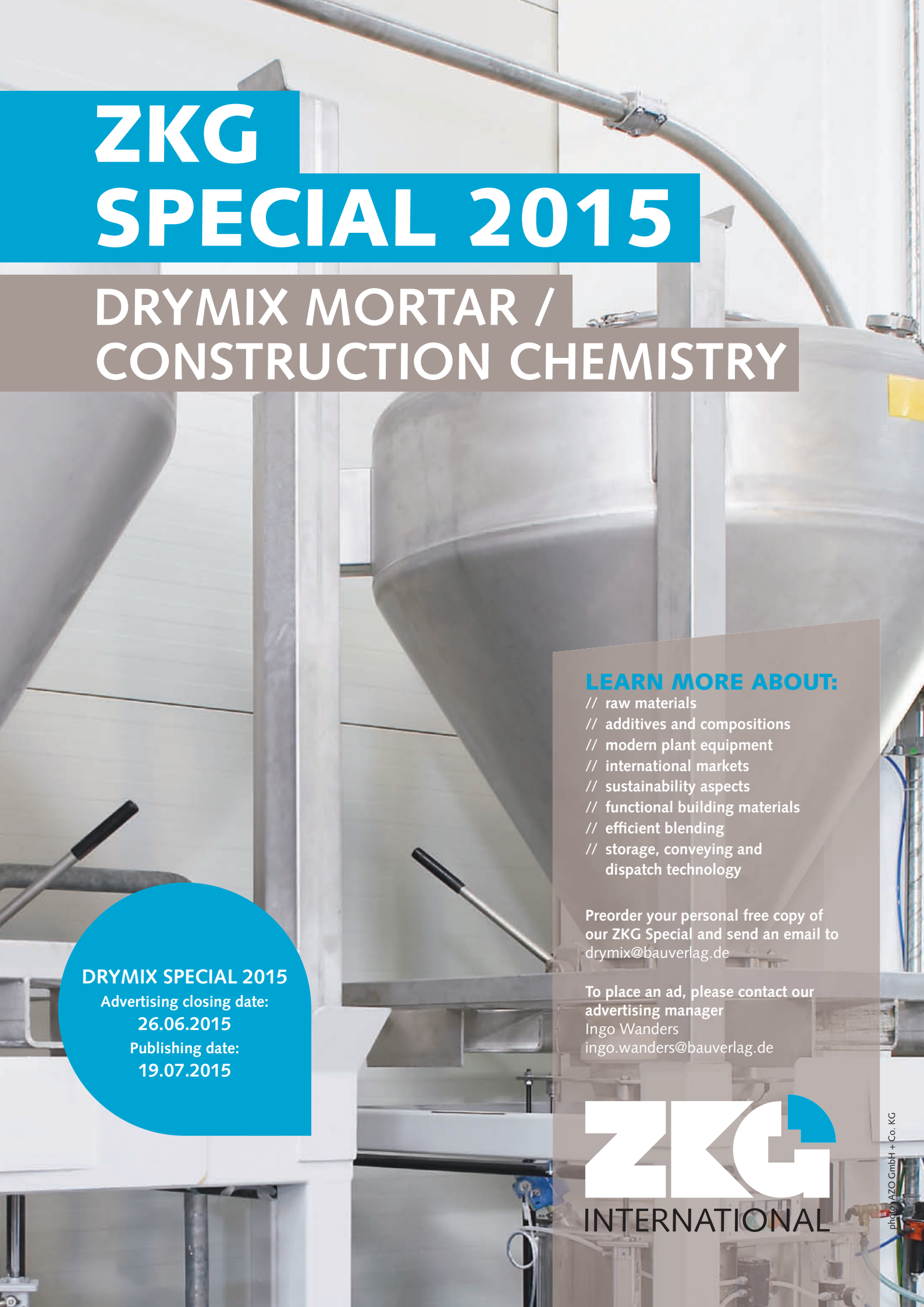

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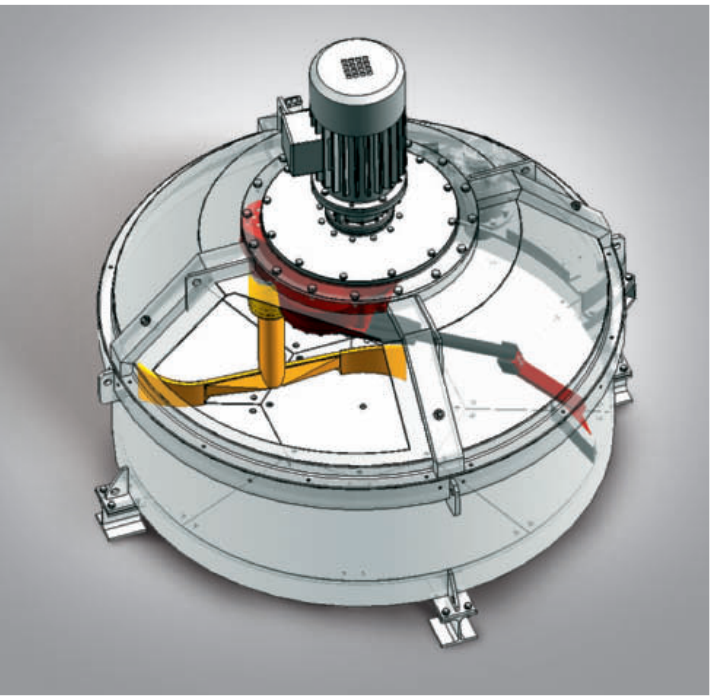

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