www.zkg.de
Cement Lime Gypsum
Zement Kalk Gips

ISSUE
2015

ZKG INTERNATIONAL

SPECIAL 2015 //
Drymix Mortar
Construction Chemistry

DRYMIX MORTAR
CONSTRUCTION CHEMISTRY

Anke Bracht
Editor // ZKG INTERNATIONAL

In 2015, too, ...

... a special issue of ZKG International is again dedicated to the subject of Drymix Mortar | Construction Chemistry. For the third year now, ZKG takes a look over the "(cement) garden fence" and focuses on the broad range of applications for cementitious materials.

These are as diverse as the drymix mortar industry itself. A very good impression of this was again provided at the biennial International Drymix Mortar Conference, idmmc 5, in April, at which the drymix mortar community met in Nuremberg during the run-up to the European Coatings Show. You can read our report on the event on page 18 in our "Events" section.

Company news and recent developments in the industry are compiled under our "Spotlight" heading. This is followed by new products in sectors such as water-repellence, polymer binders, repair mortars, cementitious tile adhesives, decanting and packing.

Our article on the planning and construction of a plant in the Ural region then provides an insight into the Russian drymix mortar industry (p. 28). The successful cooperation between a range of different companies in the Middle East/North Africa (MENA) region is featured from p. 26 onward.

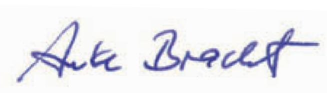
Finally, specialist articles round off the range of information packed into this year's special edition: the advantages of the buttering method are examined (p. 34). In the "Materials" sector, the first article researches the special features of lapilli cement mortar from the Canary Islands (p. 48).

The effects of new silicone resin-based hydrophobic powders on the drymix mortar market are then discussed (p. 42), as is a new binder technology for 2K fast curing waterproofing membranes (p. 56). The article on p. 38 takes as its topic the reduction of the harmful effects on human health of soluble chromates during mortar production.

We wish all our readers stimulating and interesting reading!

Yours most sincerely

Anke Bracht
Editor ZKG International



ZKG INTERNATIONAL

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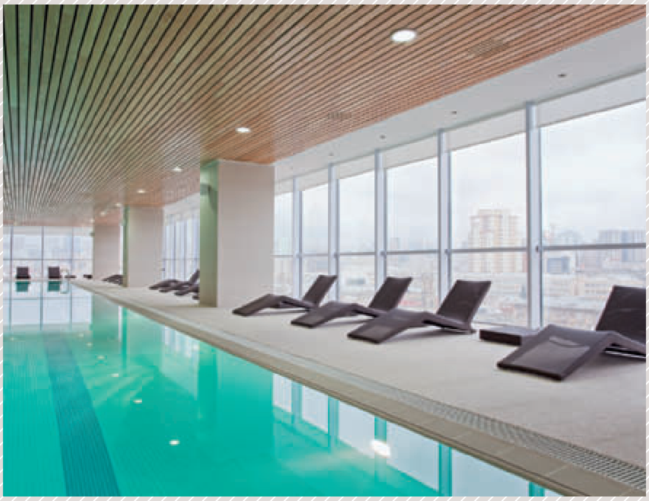
Volume 68 „ZKG INTERNATIONAL“
Volume 104 „ZEMENT“

// Page 18
The drymix mortar community keeps itself well informed

// Page 42
New silicone resin-based hydrophobic powder for the drymix market



// Page 56
New binder technology for 2K fast curing waterproofing membranes

Official Journal
Federal German Association of the Lime Industry
Bundesverband der Deutschen Kalkindustrie e.V.
Federal German Association of the Gypsum Industry
Bundesverband der Gipsindustrie e.V.

This issue's front cover shows Mondi's brand-new HYBRID[PRO] – the company's next generation of water-repellent paper bags. The HYBRID[PRO] bag is especially designed for building materials such as gypsum or cement. The traditional bag construction is turned inside out to have the HDPE layer as an outer ply. Thus HYBRID[PRO] offers uncompromising weather protection and significantly extends the shelf life of its contents, while being completely compatible with traditional paper bag filling equipment. Find out more about HYBRID[PRO] www.mondigroup.com/hybrid-pro

BAUHAUS UNIVERSITY WEIMAR

19th International Conference on Building Materials "ibausil"

All: BFT International

Professor Horst-Michael Ludwig welcomed the participants at the last ibausil in 2012

Ibausil, the International Conference on Building Materials, will take place in Weimar already for the 19th time on 16.09.-18.09.2015. Headed by the Director of the F.A. Finger Institute for Building Materials Prof. Dr.-Ing. Horst-Michael Ludwig, the program of lectures will focus on questions concerning the development of construction materials and their application. Focal points of the conference are traditionally: inorganic binders, concretes and durability of concretes as well as walling materials, building preservation and recycling.

Scientists, industry representatives and interested parties from 40 countries attended the ibausil in 2012

You will find more information about the lecture topics as well as registration for the lectures at: www.ibausil.de

MASCHINENFABRIK GUSTAV EIRICH

El-Khayyat starts construction of twin line mortar plant in Yanbu

EL-Khayyat Jeddah, Kingdom of Saudi Arabia, has recently signed the contract with Maschinenfabrik Gustav Eirich, Hardheim/Germany, for construction, supply and commissioning of an automated dry mix mortar plant with a capacity of up to 2 x 100 t/h. The plant consists of two separate mixing lines, each with one Eirich 3000 l high intensity mixer. The engineering of the whole preparation plant, from raw material preparation and storage, dosing, weighing and mixing to the bagging of the ready mixed product is done by Maschinenfabrik Gustav Eirich.

www.eirich.com

BT-WOLFGANG BINDER

New mixing plant in Malaysia built by BT-Wolfgang Binder

BT-Wolfgang Binder

The new dry building material mixing plant in Malaysia

In November 2013, Mapei awarded a contract for the construction of a new dry building material mixing plant to the Austrian general contractor BT-Wolfgang Binder GmbH.

The contractor carried out the entire planning, construction, production and delivery of the machines, the silos and the steel structure, including the façade. The silos, the steel structure as well as the tanks and containers were built in Malaysia according to the statics and manufacturing drawings provided by the general contractor. The machines were packed for carriage overseas and dispatched in containers to Malaysia from Koper, Slovenia.

Chief erectors and a supervisor deployed by BT-Wolfgang Binder performed the assembly, assisted by Malaysian personnel. The concrete foundations and the electrical installations were provided by the customer. In mid-October 2014, the plant was successfully handed over and production in Nilai in central Malaysia could begin.

At full capacity, some 35 t of adhesive and mortars can be manufactured in the new factory per hour. The delivered raw materials such as cements, sands and binding agents are being stored in the following silos: four main component silos with a capacity of 60 m^3 each as well as six main component silos with a capacity of 12 m^3 each. Dosing screws in hopper scales perform the dosing process whereas the dosing of additives is taken care of by small component scales. The plant includes six additive containers with a capacity of 2 m^3 each and a fibre box. From the scales, the material is fed into the batch mixer which has a net capacity of 2400 l.

The plant could be handed over and commissioned according to schedule despite the great distances. During handover Mapei ordered another dry building material mixing plant for Australia at BT-Wolfgang Binder.

www.btw-binder.com

DENNERT PORAVER

Dennert Poraver GmbH builds third plant in Schlüsselfeld

Dennert Poraver GmbH

1 The main plant in Postbauer-Heng with an annual production capacity of 240000 m^3

Planning works for the construction of a third production site for Poraver expanded glass granulate are in full swing at Dennert Poraver GmbH. On a site area of over 43 000 m^2, the new plant will have an annual production capacity of 160 000 m^3 of Poraver and should be operational starting in 2019. With the third plant, the company's total annual production capacity at its sites in Germany and Canada will be increased to 500 000 m^3.

Poraver expanded glass granulate is a lightweight aggregate for high-quality building materials and industrial products. Due to the wide range of applications in various industrial areas, demand has been growing steadily in recent years. In 2014, the annual production capacity of the main plant in Postbauer-Heng was already expanded to 240 000 m^3 by a fifth production line.

For the scheduled commissioning in 2019, 40 new employees are being hired for the production and logistics department at the new production site; in the long term, more than 100 people will be employed at the new plant. The importance attached to innovative products by the company is underlined by the construction of a laboratory for the field of application technology as well as by yet another laboratory for research and development already under construction in Schlüsselfeld.

www.poraver.com

ICCC

14th International Congress on the Chemistry of Cement (ICCC 2015)

The 14th International Congress on the Chemistry of Cement (ICCC 2015) will take place in Beijing/China from 13.10.-16.10.2015. Since the first International Congress on the Chemistry of Cement started in London/UK in 1918, it has become the most influential routine congress for promoting worldwide cooperation and communication on the chemistry of cement and concrete technology. It focuses on how cement and concrete contribute to global sustainability. The past decade has witnessed rapid progress in cement science and a significant increase in the number of attendees participating at the ICCC. Around 1000 scientists attended the last ICCC 2011 in Madrid/Spain.

All the previous events have aroused interest in cement and concrete circles and attracted a great number of scientific professionals, including many world famous experts. The ICCC 2015 will demonstrate low carbon cement and green development worldwide, and renowned experts from all over the world will be invited to present their work at the ICCC 2015. The scientific program will feature topics of the latest research and development covering clinker chemistry (incl. process technology), hydration of Portland cement, SCMs, admixtures, alternative binders, durability of concrete as well as standards and codes.

www.iccc2015beijing.org

DRYMIX.INFO

Events focussing on Latin America this autumn

Central American Drymix Mortar Meeting

The International Community for Drymix Mortars invites mortar experts from Central and South America as well as the Caribbean to join the first Central American Drymix Mortar Meeting. The event takes place in Mexico City, Mexico on 14.09.2015.

4^{th} Latin American Drymix Mortar Conference ladmmc four

The 4^{th} Latin American Drymix Mortar Conference ladmmc four takes place in São Paulo/Brazil on 06.11.2015. This traditional, full-day conference is the only one entirely focussed on drymix mortar in South America and unites the experts from this area with delegates from the US, Europe and elsewhere. A comprehensive lecture programme featuring 12 scientific speeches by industry experts has been chosen by Mario Kristeller, the Technical Chairman of ladmmc four. The programme has been published on www.drymix.info, it is also available in Portuguese. Simultaneous translation Portuguese – English – Portuguese is offered for all delegates.

Both events will feature comprehensive technical lectures, an industry showcase and provide ample networking time for all delegates.

www.drymix.info

MASCHINENFABRIK GUSTAV EIRICH

Dry mortar production plant at the Maco Group in Beijing

At the Maco Group in Beijing/China installation work is currently underway at full speed for a dry mortar production plant planned by Eirich for more than 100 raw materials in two production lines. Commissioning is scheduled for 2015. Maco awarded Eirich the contract for the engineering and the delivery of the key components of the new plant (mixers, batching systems, scales, control systems). One of the two lines will be ATEX-conform.

The two Eirich RV24 (2 x 3000 l) intensive mixers used at Maco require no choppers for system-related reasons: the disintegration of the fines is achieved thanks to the high Froude numbers of the mixing tool.

In order to meet requirements in terms of the high quality standards and the diversity of the large and small components, today‘s dry mortar production plants are almost completely automated. For the Maco project this means that more than 100 components have to be batched via over 30 scales, some of which are accurate to within +/- 5 g.

www.eirich.com

MC-BAUCHEMIE

New R2 and R3 repair mortars complete the Nafufill concrete replacement portfolio

MC-Bauchemie

The new R2 mortar Nafufill 230 KM exhibits good properties and can be applied in layers ranging from 6 to 60 mm thick, either as a partial or a full-surface repair coating

The concrete replacement systems Nafufill LM and Nafufill KM 250 have a highly successful track record in the repair of both structural and non-structural concrete components. Now, with Nafufill KM 220 and Nafufill KM 230, MC-Bauchemie has developed two further concrete replacement systems offering new options to planning engineers and specifiers faced with finding the right repair solution.

While concrete repairs in Germany are preferentially aligned to the planning and execution requirements specified in the national standards ZTV-ING (Additional Technical Terms of Contract and Guidelines for Engineered Structures) or DAfStb (German Committee for Reinforced Concrete), in many other countries the European repair standard EN 1504 is exclusively applied for such work, not least because of the strength categories it specifies. In EN 1504 Part 3, repair mortar (concrete replacement) is classified as follows: R1 (compressive strength ≥ 10 N/mm^2), R2 (compressive strength ≥ 15 N/mm^2), R3 (compressive strength ≥ 25 N/mm^2) and R4 (compressive strength ≥ 45 N/mm^2). Given the different categories applied to ageing concrete, this makes complete sense.

Now, with Nafufill LM, Nafufill KM 220, Nafufill KM 230 and Nafufill KM 250, there are four types of repair mortar (concrete replacement) available that not only more than meet the requirements of EN 1504 Part 3, but also provide planners/specifiers with the security they need in tackling specific job requirements.

Nafufill KM 220 – Class R2 repair mortar

Nafufill KM 220 is a single-component, polymer-modified and fibre-reinforced mortar suitable for the surface repair of normal, lightweight and chipped brick concrete in structurally irrelevant areas of industrial buildings, civil engineering and residential construction. It is applied without a bond coat and is ideal for the reprofiling of fractured or broken surfaces, the application of levelling coats and fine filling work in layer thicknesses ranging from 3 to 30 mm. After 28 days at 23 °C and 50 % relative humidity, Nafufill KM 220 attains a compressive strength value of 24.5 N/mm^2. It is manually applied and, with low consumption values per unit area, offers high yield and thus good cost-efficiency.

Nafufill KM 230 – Class R3 repair mortar

Nafufill KM 230 is a single-component, polymer-modified and fibre-reinforced mortar (PCC concrete replacement) suitable for the surface repair of engineered concrete construction components as used in structurally relevant areas of industrial buildings, civil engineering and residential construction. After 28 days at 23 °C and 50 % relative humiditity, Nafufill KM 230 attains a compressive strength value of 34 N/mm^2. It can be applied in layers ranging from 6 to 60 mm thick, either as a partial or a full-surface repair coating. It can be both manually trowelled and sprayed and is characterised by its outstanding application properties. It is temperature and frost/thaw cycle resistant and exhibits also a de-icing salt resistance. With a fresh mortar application density of less than 2 $kg/m^2/mm$, this product likewise offers exceptionally low consumption values.

www.mc-bauchemie.com

Sika® ViscoCrete® AND Retardan® HIGH PERFORMANCE ADDITIVES

NEW: Sika® ViscoCrete®-510 P AND Sika® ViscoCrete®-520 P

If the production of consistent, high quality yet economical and low emission dry mortars is your goal, Sika additives are your solution.

Sika® ViscoCrete®
Superplasticizers, which are extremely efficient and provide excellent flow characteristics.

Sika® Retardan®
Very effective gypsum retarders, showing excellent performance in the adjustment of setting and workability time.

SIKA DEUTSCHLAND GMBH
Peter-Schuhmacher-Str. 8 · D-69181 Leimen · Germany
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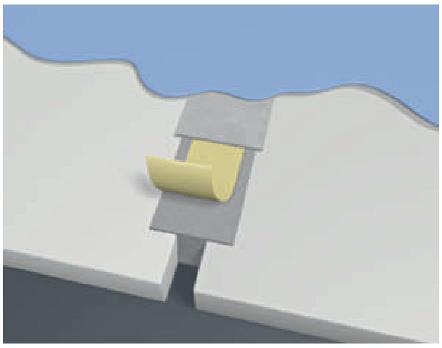
www.sika.de

WACKER CHEMIE

A new polymeric binder for gypsum-based grout mortars

All: Wacker Chemie AG

1 Gypsum joint in a drywall



2 Application of joint filler and paper band between plasterboards

Wacker's VINNAPAS® 4800 G is a specially-developed polymeric binder for gypsum-based joint fillers in drywall technology: It not only improves tensile adhesive strength, but also the mortar's processability. Plus, it allows the formulation of low-emission products.

The advantages of drywall technology also increase gypsum plasterboard production. Today, over one third of global gypsum production flows into the manufacture of gypsum boards. According to Global Gypsum estimates, worldwide demand for gypsum board is set to grow by 8.6 % annually by 2016 and reach a surface area of 10.7 billion m^2. Global Gypsum attributes 70 % of this additional demand alone to China and its rapidly growing housing-construction market.*

As the demand for interior finishing rises, the necessary materials must offer ever-increasing quality and ease of processing. Polymeric binders are a key component of these materials, such as jointing compounds and joint fillers. They ensure the necessary stability, adhesion and flexibility in gypsum mortar. With VINNAPAS® 4800 G, Wacker has developed a new dispersible polymer powder that meets rising interior-finishing requirements (Fig. 1).

* Global Gypsum Magazine, September 2014, p. 16

Stable joints and homogeneous surfaces

The product was specifically designed for gypsum drymix mortars used as jointing compounds and joint fillers in drywall applications. These are necessary to smooth out joints that form following the installation of gypsum blocks. Usually, a so-called reinforcing strip made of paper, glass fiber or specialty nonwovens is placed on the joint and plastered over. This increases the joint's stability and reduces the risk of cracks forming (Fig. 2). At the same time, jointing compounds modified with VINNAPAS® 4800 G offer further advantages. They are easier to process – and require fewer coats to achieve a smooth surface. Moreover, the binder ensures that uneven surfaces and edges are leveled out, resulting in a particularly homogeneous surface. A smooth surface is of primary importance for subsequent wallpapering.

Better adhesion and bonding strength

VINNAPAS® 4800 G dispersible polymer powder is based on vinyl acetate and ethylene and was specially developed for the improvement of gypsum-based joint-filler compounds. It imparts outstanding adhesion, both to gypsum plaster-board and reinforcing strips. That ensures higher overall mechanical strength of the joint structure.

The binder serves as an adhesion promoter between the organic paper and the inorganic gypsum. The formation of polymer bridges between the two substrates creates a very resilient bond. VINNAPAS® 4800 G is impressive in adhesion tests – such as the paper-strip test (Fig. 3), which is primarily used on the French market. Gypsum drymix mortars modified with Wacker dispersible polymer powder withstand a tensile force of some 2000 grams. By comparison, mortars without a binder show a value of 200 grams in laboratory trials.

Environmentally compatible end products

A further key aspect of interior finishing is that, as far as possible, materials do not emit any pollutants. Wacker binders perform well here, too: VINNAPAS® 4800 G is free of plasticizing additives that could be emitted as volatile organic compounds (VOCs) into the air. Due to its flexible ethylene segments, there's no need for adding any plasticizer, which enables the formulation of low-emission end products. This dispersible polymer powder is therefore ideal for improving environmentally compatible gypsum-based drymix mortars such as joint fillers and jointing compounds for interior finishing.

Thus, Wacker offers an ideal product for processing gypsum, which is also known to be a "green" material. The reason is that relatively low temperatures of just 200 °C are needed for its manufacture. With synthetic gypsum, also known as flue gas desulfurized gypsum (FGD gypsum), even harmful air-polluting compounds can be neutralized permanently. In addition, the gypsum plasterboard itself is easy to recycle.

www.wacker.com

3 Lab test of tensile adhesion strength

BEUMER GROUP

Bag after bag – continuous and exact filling process

All: Beumer Group GmbH & Co.

1 Beumer has added the rotating filling machine fillpac® to its product portfolio and equipped it with extensive features

Cement, mortar or gypsum – the bulk density, flow characteristics and grain distribution of these products, which are filled in bags and packed for delivery to the customer, may vary significantly. Building materials have their own specific characteristics, such as high product temperatures or different volumes and weights – they may show an unusual flow behaviour and may be dimensionally unstable. As a partner to this industry, the Beumer Group from Beckum/Germany successfully enable material manufacturers to fill bags without any product loss with the Beumer fillpac®, an efficient filling machine. The systems of this construction series fill reliably, carefully and sustainably while meeting the required throughput.

Precision filling

The fillpac® is equipped with a weighing unit, which communicates permanently with the filler neck via a dedicated software. The automatic bag weight control determines the exact filling weight while filling. This way the system always achieves accurate degrees of filling. Thus the packaging line works more efficiently as it is no longer necessary to remove under- or overweight bags from the material flow. In addition, the quantity indicated on the bag always corresponds to the real volume.

Air filling machines

Depending on the requirements and on the material characteristics such as bulk density, flow behaviour or grain distribution, Beumer can offer both air and turbine filling machines from the construction series. The air filling machines are suitable for bagging pourable and coarse-grained products with particle sizes up to ten millimetres. The systems use a blower to fluidise the materials in a pressure chamber. The products can then be filled into bags gently and precisely. Depending on the throughput, the user may opt for a rotary or an inline filling machine. The air rotary filling machines have four to twelve filling modules which are arranged in a circular pattern. Depending on the number of filling spouts, the systems reach a maximum capacity of 1200 to 3600 bags per hour for 25-kilo bags.

2 The fillpac®, equipped with the Beumer bag discharge line SA 4000

The air inline filling machines are generally equipped with one to four filling modules. Depending on the number of filling spouts positioned next to each other, the system achieves a capacity reaching between 300 and 1200 25-kg-bags per hour. Regardless of whether the system is arranged in a circular pattern or in a line, capacity and utilisation can be improved by installing an optional automatic bag placer. The filling process is carried out either automatically or at the push of a button. Two configurations are available for removing the bag at the end of the filling process: either manually or automatically with vertical bag discharge on a belt conveyor.

Turbine filling machine

The turbine process is the appropriate solution for companies which predominantly fill free-flowing and fine-grained materials, such as cement or gypsum. The turbine filling machines use motor-driven impellers. They can be arranged either horizontally or vertically, ensuring a particularly high filling pressure and thus a very good compaction of the fine-grained materials to be bagged. The result is filled bags which are compact and dimensionally stable so that the user is no longer required to vent them.

With up to 20 filling modules, the Beumer fillpac® R for example can fill up to 300 tons of fine-grain materials per hour into diverse bag types. The HDPE bag placer enables dependable filling of HDPE bags. The filling impeller is characterised by its speed and the maximum material throughput. The bag weight adjustment, which automatically adjusts the weight of the next bag, always ensures precise results. Opening and closing of the vertically mounted filling spout is carried out outside of the dirty area – this way the three-position cylinder which regulates the coarse and fine flow is protected from dust. The cylinder for bag discharging is also located in the dust-free zone above the filling spout. This solution minimises wear and tear on both cylinders and, therefore, ensures longer service life.

Beumer also offers the turbine filling machines with inline design. The filling modules are placed next to each other for ready access, which makes them extremely easy to maintain. The inline filling machines are best suited for production environments with low throughput rates.

Individual customisation

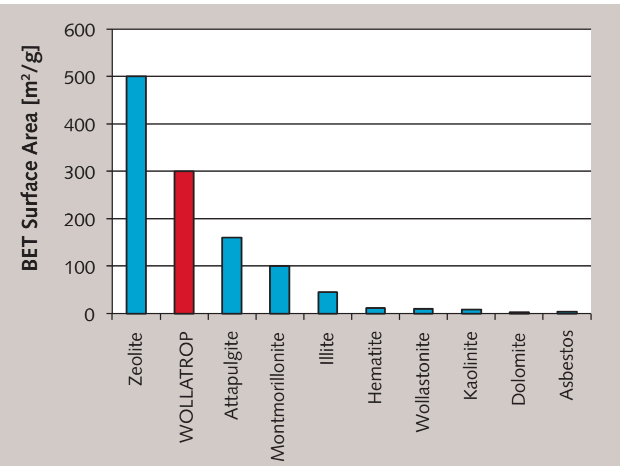
The Beumer construction series is equipped with an ergonomic control terminal. The improved Human Machine Interface concept allows operators to work in a simple and intuitive way. Almost all built-in components of the Beumer fillpac® are freely available commercially. This reduces delivery times for spare parts and lowers capital costs for the user. Furthermore, the intralogistics supplier has designed the system in a way that individual customer requirements or special operational requests can be implemented flexibly and cost-effectively.

www.beumergroup.com

OSTHOFF OMEGA GROUP

Alternative inorganic rheology modifier

Drymix systems are manufactured for various applications such as tile adhesive, joint grouts, renderings (gypsum and cementitious), EIFS, repair mortars and masonry mortars. This diversity requires the use of specially formulated products. Precise adjustment of the rheological properties enables the use of dry mix systems for a wide variety of applications and application methods.

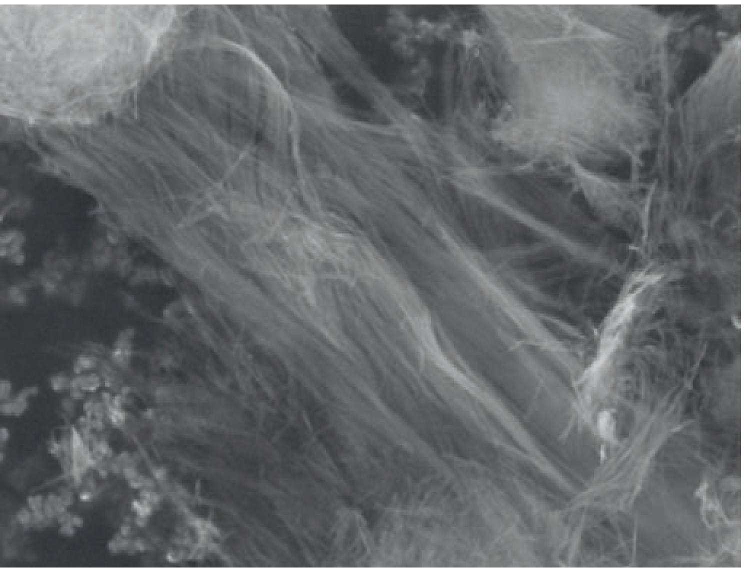


All: Osthoff Omega Group

1 Comparison BET of various minerals according to DIN 66131

The use of rheological active agents, ensures control of parameters like workability, sagging control, pumpability and resulting surface quality. In addition, to adjust properties, rheological active agents should have no adverse impact on important properties; if possible these parameters should be positively influenced:

» water demand
» open time
» correction time (tile adhesives)
» set retardation
» wet adhesion to substrates
» adhesion in the cured state
» durability of contact materials
» bleeding
» water resistance
» steam permeability



2 SEM image (in aqueous environment) dispersing Wollatrop

- freeze/thaw resistance
- crack bridging or prevention

Wollatrop, now available for use in drymix mortars, is an innovative inorganic silicate-based rheology modifier agent for aqueous systems. It allows adjustment and therefore optimisation of workability, wet adhesion to substrates and adhesion to surface in the hardened state, sag resistance, pumpability, and final surface finish without the development of cracks or bleeding.

The use of adequate amounts Wollatrop, does not affect open time, durability, setting properties, correction time, water demand, water resistance or heat resistance.

The rheological effect of Wollatrop is based on the enormous large surface area (Fig. 1), in conjunction with structure and chemical composition. The high concentration of Si-OH groups on the surface, allows thixotropy causing interaction with organic and inorganic formulation components.

A further advantage is the easy incorporation into drymix systems. Wollatrop disperse easily in water (Fig. 2) thereby it is a safe-to-use, inorganic economical alternative to control the rheological properties. The low cation exchange capacity ensures over a wide pH range (3-14) stable and efficient control of rheology.

Wollatrop is classified as group 3 product by the IARC and therefore to be regarded as a safe product. Unlike organic thickeners, it requires no preservatives.

Depending on the desired rheological effect Wollatrop can be used alone or in combination with a traditional rheology modifier for example cellulosic ether. When used alone, like in pumping mortars the recommended Wollatrop quantity is between 1 % and 1.5 %. For tile adhesives 20 to 30 % of traditional cellulosic thickener can be replaced in a ratio of 2:1 (Wollatrop : Cellulosic ether).

www.osthoffomegagroup.com

ASHLAND

Culminal™ Plus for additional security in premium cementitious tile adhesives

Culminal Plus is a new series of modified methylcelluloses for use in premium cementitious tile adhesives. Cementitious tile adhesives are clearly specified in EN 12004/ISO 13007 as to their performance. All tests are typically done under well-controlled laboratory conditions specifying temperature, humidity and substrate. Often formulations are designed to meet the norms but when it comes to practical application in the field the conditions always differ and lead to lower performance and, in the worst case, to costly complaints. Culminal Plus was designed by Ashlands research & development experts to improve important tile cement properties and give additional security.

The main benefits of using Culminal Plus versus commonly used methylcellulose based rheology modifiers are:

» Better "transfer" of adhesive through improved open time
When tilers apply tile adhesive typically a larger area is covered before tiles are placed. Due to the longer visual open time and resulting improved contact area using Culminal Plus better bonding and higher strength values are achieved. This is especially important when larger format tiles are placed. Ideally the reverse side of each tile, even when applied after a long time, should be fully covered with adhesive after the tile is placed and pressed into the mortar. This to secure maximum adhesion.

» Optimized fracture patterns
Culminal Plus improves the fracture pattern significantly in three formulations shown in the Figure. All tested products show an improved fracture pattern and it is obvious that the Culminal Plus containing products show 100 % cohesion failure after norm storage.

» Higher strength values after longer embedding time
Especially when application conditions in the field (higher temperature, low humidity, wind, strong absorbing substrates) increase the risk of early skin formation on the adhesive surface it is important to maximize open time. Culminal Plus allows easier development of formulations classified as "tile adhesives with long open time (e.g. C2TE)".

The higher the strength values even after long embedding time, the higher the probability of the tile adhesive to show also excellent performance under practice conditions.

Comparing Culminal Plus with a standard methylcellulose shows that after short embedding time the strength values are comparable. The product containing Culminal Plus, however, shows clearly higher strength values when tiles are embedded after a longer time.
www.ashland.com/culminalplus

In three formulations, Culminal Plus improves the fracture pattern

CTA 1 Eastern Europe | **CTA 2 Asia Pacific** | **CTA 3 Western Europe**

Determination of tensile strength after 28 days dry storage

WACKER

Highly efficient water repellent for gypsum drymix mortars

Wacker

Gypsum-based building materials formulated with SILRES® BS Powder S are thoroughly water-repellent. Gypsum plasters and the jointing compounds used in drywall building are protected from water and thus against irreversible damage

Moisture can do irreparable damage to gypsum building materials. To prevent this and to protect the set gypsum mortar against moisture, powder-form water-repellent agents are admixed to the dry-mix mortar. This requires manufacturers of standard powder-form water repellents to employ carrier or encapsulation materials as a way of converting the liquid active ingredients into a powder. These additives delay the onset of the hydrophobic effect of the liquid water repellent until the mixture of gypsum mortar and water has set. The disadvantage of such additives, however, is that they are composed almost entirely of carrier material. The actual active ingredient constitutes just a few weight percent of the formulation – which is not very efficient in terms of either weight or cost.

The solution here is to use SILRES® BS Powder S. This new additive for dry-mix mortars does not require any additional additives, consists entirely of a novel, active powder ingredient and so is extraordinarily efficient. Just 0.2 wt-% of it is enough to make gypsum building material water-repellent. Gypsum containing the new additive absorbs up to 90 % less water when set and can be employed in bathrooms, kitchens, stairwells and garages. Gypsum-based wall plasters, joint fillers and adhesives that have been formulated with the additive are thus suitable for use throughout house interiors.

SILRES® BS Powder S consists of a methyl siliconate which is produced as a colorless, free-flowing powder by a special process. The active ingredient is inherently soluble in water, a property which confers excellent mixing properties when the mortar is being prepared. Nonetheless, the gypsum mortar is water-repellent as soon as it sets.

The repellant can be used with all types of gypsum dry mix mortars, irrespective of the pH. It eliminates the prereaction times which are often needed by conventional powder-form water-repellent agents. The additive even supports the formulation of Type H1 gypsum jointing compounds that meet the highest requirements for reduced water absorption. According to Standard EN 13963:2014, which was revised last year, Type H1 joint fillers must absorb no more than 5 wt-% water after setting.

www.wacker.com

PE bag with high water-tightness

All: Haver & Boecker

HAVER & BOECKER

Clean, efficient … and excellent in every sense of the word

Bags made of polyethylene (PE) are suitable for many requirements, and are used for transportation and sales of many consumer goods. Yet, who would have imagined some years ago that powder-type construction materials could also be filled into compact and weatherproof PE bags in an environment-friendly process? Haver & Boecker took the initiative: The result is a form-fill-seal system named ADAMS®.

"With the ADAMS® we have developed a filling machine for PE bags that offers a series of advantages," explained Burkhard Reploh, General Manager Haver Building Products & Minerals. "The PE bags used are characterized by excellent water-tightness and resistance to tearing. Bag damage and ruptures during filling can be reduced by an average of 80 to 90 %," added Heinz-Werner Bunse, Sales Manager of Haver Cement.

Packing into PE bags enables customers to benefit from a series of advantages. During filling and transport there is a comparably lower level of product loss. Cost savings in transport are the result of reduced freight volume and the elimination of additional protective packaging. "Less bag breakage, high levels of weight accuracy, improved health protection from a dust-free solution and CO_2 savings with 100 % recyclable material lead to significantly higher customer satisfaction," said Burkhard Reploh, who is convinced of the technology which is meanwhile installed in more than 70 plants.

Heinz-Werner Bunse experienced the development of the bags first hand: Approximately 49 years ago the technician began his apprenticeship at Haver & Boecker. Back then he was familiar with the use of jute sacks. "During the 1920s, when the technology was developed, there was a huge technical development in this segment," said Bunse while summarizing his impressions of the decades-long innovation management. They were customized to suit the individual needs of various industrial branches, and increasingly more efficient solutions were brought to the market. "The filling of PE bags expands the opportunities in the global building material market and creates options that improve and simplify the weather-proof storage of goods," said Bunse. Burkhard

Burkhard Reploh, General Manager Haver Building Products & Minerals

Heinz-Werner Bunse, Sales Manager of Haver Cement

The Haver ADAMS® system in operation at a Lafarge plant, Cookstown/UK

Reploh added: "Currently some 10 % of all bags do not reach their point of destination – mainly because of inadequate shelf life and bag breakage. This error rate can be greatly reduced by using PE bags." He proudly pointed to more than 70 references in 18 countries where the ADAMS® technology has been in use since 2005. Here the scrap amount has been reduced to almost zero. These machines were designed to handle 5-50 kg bags.

A new development for PE-bagging pouches called Haver & Boecker ROTO-PACKER ADAMS® MINI can fill pouches from 1-10 kg and is opening up totally new perspectives for building material producers. The results are very nice compact pouches for DIY-stores with an optimum of compactness and display.

All these advantages result to a great extent also from the innovative vibration technology and the dust-tightness of the process, which in the end assures a clean final product. "With the ADAMS® we have succeeded in developing a technology that fulfills all the market requirements when it comes to improving storage capacity and product cleanliness," elaborated Burkhard Reploh. Once the filling of powder-type products into PE bags had gained acceptance on the market, an Innovation Management team went to work on a Haver & Boecker ROTO-PACKER ADAMS® MINI. The team used past experience with the technology and developed new, detailed solutions for small pouches which are to be on display in the standing position in the DIY-stores.

The new machine forms a tube from a flat film. The pouches are then placed in open cassettes arranged in a circle on a rotating unit. The product is filled step-by-step, precisely dosed and compacted. A hermetically sealed package that provides optimum protection against moisture is the final result.

"The ADAMS® technology for industrial bag sizes is foremost suitable for countries where processes such as loading and unloading are mostly done manually. At the same time the technology is suitable for climatic conditions where the material has to be protected from the weather elements," said Heinz-Werner Bunse. However, this not only makes the ADAMS® technology a leading export for Africa, Asia and South America: "We are sure that also customers all across Europe will be convinced of the advantages of this technology."

"The high level of automation requires an operator skill profile that is more than what we were used to seeing in the past," admitted Burkhard Reploh. However with the right training it is absolutely possible to rely on a single person for the operations and monitoring of various machines. For this case the HAVER specialists have created a training program that includes the aspects of material flow, PE-film specification and bag handling.

Aspects such as recycling and re-use of PE material are especially important factors in countries where manual handling was common in transport and storage. "Filling powder products into PE bags will define a new industrial standard," Burkhard Reploh is convinced.
www.packyourpowder.com

The dust-tightness of the process ensures a clean final product

5TH INTERNATIONAL DRYMIX MORTAR CONFERENCE IDMMC FIVE, NUREMBERG/GERMANY (20.04.2015)

The drymix mortar community keeps itself well informed

TEXT **Anke Bracht M.A.**, ZKG International

All: ZKG International

1 More than 175 participants attended the idmmc five in Nuremberg

2 Ferdinand Leopolder and Prof. Dr. Johann Plank welcome the participants

For the fifth time, Ferdinand Leopolder of drymix.info issued an invitation to the International Drymix Mortar Conference (idmmc five) in Nuremberg on 20.04.2015. This event for the international drymix mortar community takes place every two years. As in recent years, the date was coordinated with the European Coatings Show, which was held immediately afterwards in Nuremberg. On the evening before the conference, the majority of the drymix mortar community already met for a convivial evening at the Nuremberg Barfüßer Mautkeller tavern, originally a granary built in 1500. The rustic ambience and relaxed atmosphere presented an early opportunity to exchange experience and engage in networking.

Ferdinand Leopolder, together with the Technical Chairman, Prof. Dr. Johann Plank of the Technical University of Munich, were then able to welcome more than 175 participants in the small Meistersingerhalle on 20.04.2015. The conference was accompanied by an industry exhibition, at which plant manufacturers and suppliers for the mortar industry presented their products and were available for questions from interested parties.

The conference started off with a presentation by Matteo Monaco, Mapei S.p.A, Milan/Italy, entitled **"Statistical evaluation of pull-off adherence tests according to ISO 13007"**. Data dispersion is the fundamental parameter when choosing a well performing substrate. The distribution of adhesion pull-off data on different substrates was analyzed statistically. This was supported by a round robin test between three laboratories of the Mapei Group.

Dr. Marga Perello, Dow Europe GmbH, Horgen/Switzerland, spoke on the subject of a **"New generation of binders for 2K fast drying waterproofing membranes"**. The fast curing of a waterproofing membrane is an important attribute with regard to the cost and time expended when applying a second membrane. The aim was to develop new latexes combined with a fast drymix that ensure a superior waterproofing performance, very high flexibility and crack bridging, as well as elongation retention after water swelling.

"Calcium sulphoaluminate based cements: a sustainable solution for dry mortar production" was the title of the lecture by Dr. Maurizio Iler Marchi, Italcementi Group, Bergamo/Italy. Calcium sulphoaluminate cements (CSA) have recently become regarded as "green" binders, as they generate a small amount of CO_2 during the clinkering process and during grinding. In addition to this, they are made by using a wide range of industrial by-products. Therefore, CSA cements could be used as main or secondary constituents in different applications. After showing different examples of applications, the main advantages of CSA cements for drymix mortar production were presented.

Prof. Dr. Johann Plank acted as chairman of the first lecture session. He also moderated the subsequent lively discussion on the individual contributions. All in all, the conference was characterized by the very high quality of the presentations and the ensuing discussions.

The second series of lectures was chaired by Mario Kriteller, MCK Consulting, Brazil. Dr. Ömer Faruk Şen, Organik Kimya San. ve Tic. A.Ş., Istanbul/Turkey, presented the **"Effects of redispersible powder polymers' Tg on the flexibility of cementitious mortars"**. The study was based on the well-known discussion on the effects of the glass transition temperature of polymers on the flexibility of cementitious mortars. The study tried to find a different set of definitions of flexibility, while introducing results from a different test method approach.

"Performance and hydration behavior of supplementary cementitious materials in tile fixing application" was the subject dealt with by Dr. Funda Inceoğlu, Kalekim A.Ş, Istanbul/Turkey. This study investigated the benefits and limitations of supplementary cementitious materials (SCMs) as partial substitution for Portland cement in tile fixing applications. Mortars containing different amounts of SCM were examined by X-ray diffraction (XRD) and scanning electron microscope (SEM) analysis with regard to their impact on cement hydration behaviour and phases developed during the hydration reactions.

Dr. Markus Müller, Sika Services AG, Baar/Switzerland, lectured on **"Targeted adjustment of mortar properties by use of polycarboxylates in various binder systems"**. Applications that require excellent flow characteristics were the basis for the evaluation of suitable new polycarboxylate ether (PCE) based superplasticizers. Typical applications are grouts and self-levelling compounds which are based on cement, gypsum and ternary binder systems. Additives with a broad spectrum of applications are necessary for the purposes of the drymix mortar industry. Both environmental and economic aspects also have to be considered by the manufacturers.

In the last lecture before the lunch break, Nikolaus Kreuels, Calucem GmbH, Mannheim/Germany, spoke about **"CAC-rich self-levelling compounds with different calcium aluminate cements"**. The technical properties of CAC-rich self-levelling compounds (SLC) were investigated, replacing the CAC by different CAC grades in order to measure the variations in the SLC performance.

The series of lectures after the lunch break was chaired by Rainer Ålgars, a former research engineer at Saint Gobain Weber Finland and member of many technical committees dealing with the standardization of drymix mortars. Dr. Roger Zurbriggen, Akzo Nobel Chemicals AG, Sempach/Switzerland, started the session with the topic **"Innovations in dry mortar technology to meet latest regulations and recent trends"**. As the drymix mortar producer has to react to new requirements (trends, environmental implications etc.), the presentation focused on

3 and 4 The breaks were used for animated discussions and for gathering information at the industrial exhibition organic additives regarding formulation parameters. The relations between the additives and mineral binders and the resulting properties of drymix mortars were discussed from a material science perspective.

The presentation by Dr. Ulrike Peter, Lhoist S.A., Wawre/Belgium, was titled **"On the impact of hydrated lime in drymix mortars"**. The paper reviewed the current scientific state of the art regarding the performance of air-lime-based mortars. The impact of lime on mortar properties and performance, as well as its environmental benefits, were presented.

Axel Giesecke, Dow Corning GmbH, Wiesbaden/Germany, subsequently lectured on **"Innovative options for cement-based material protection – from FRC to drymix"**. Different new materials were presented together with their performance data. By comparing lab data of traditional and innovative methods, the aim was to show how innovative technologies can improve the performance of cement-based materials.

The first series of afternoon lectures was concluded by Dr. Klas Sorger, Wacker Chemie AG, Munich/Germany, **"A comparison of different cement types – CEM I, CEM II and CEM III – in tile adhesives and ETICS mortars"**. Due to environmental considerations, there is a change in the requirements for cement qualities when used as hydraulic binder in drymix mortars. The study compared different cement types with pure Portland cement in cementitious tile adhesives (CTA) and ETICS mortars.

The last series of lectures was chaired by Ferdinand Leopolder of drymix.info, the International Community for Drymix Mortars. Dr. Paul Nommensen, Avebe U.A., Veendam/The Netherlands, spoke on the subject of **"Controlled shear history in rheological characterization of cement- und gypsum-based construction materials"**. The study was based on an especially developed measuring protocol that imposed a fixed shear history on the sample material.

The next lecture was presented by Pascal Taquet, Kerneos S.A., Neuilly Sur Seine/France, and dealt with **"Calcium aluminate as key technology for ettringite formation – from hydration to applicative properties"**. The paper gave an overview of the different hydration reactions involved in ettringite formation and the link with applicative properties.

The conference was brought to a conclusion by the lecture held by Ludo van Nes Blessing, Caltra Nederland BV, Mijdrecht/The Netherlands, entitled **"Metakaolins produced through flash calcination"**. Metakaolins are traditionally manufactured by the rotary kiln method. The paper presented the results of the alternative production of metakaolin by flash calcination.

After a discussion of the topics, Ferdinand Leopolder wrapped up and summarized idmmc five. He cordially invited the participants to the next International Drymix Mortar Conference in two years' time. The idmmc six will take place on 03.04.–04.04.2017 in Nuremberg.
www.drymix.info

3RD EUROPEAN MORTAR SUMMIT, LISBON/PORTUGAL (21.05.–22.05.2015)

Looking back at a successful 3rd European Mortar Summit

TEXT **Antonio Caballero González,** European Mortar Industry Organisation (EMO), Brussels/Belgium

1 EMO President Carlos Duarte opening the 3rd European Mortar Summit

All: European Mortar Industry Organisation (EMO); Photographer: Jorge Correia Luís, Lisbon

The European Mortar Summit is the biennial gathering of the manufacturers of mortars, plaster and renders, adhesives, screeds and ETICS to exchange views on topical subjects and future trends. It was initiated and is hosted by the European Mortar Industry Organisation (EMO). For the 3rd European Mortar Summit on 21.05.-22.05.2015 in Lisbon/Portugal, EMO responded to the feedback from previous events by adapting the concept and extending the event's duration. For the first time the European Mortar Summit 2015 hosted both a technical and business conference, as well as a high level congress. The conference and the congress were held on two consecutive days.

Lisbon being his home town, it was a "special pleasure and honour" for Carlos Duarte, President of EMO and Secretary General of the Portuguese mortar and ETICS association APFAC, "to welcome such a great number of participants and partners to the 3rd European Mortar Summit". With a view to the market he was pleased to inform that "after years of downturn in 2014 the Portuguese market has finally seen a slight rise!" In Portugal, where site mixed mortars continue to play a very important role, the higher quality and efficiency of factory made dry mortars continues to be an important sales argument. "APFAC fights to safeguard the high quality image of factory made mortars with information and qualification schemes to ensure the appropriate products are used in the right way!"

The need for adequate information and communication was also the recurrent theme in Hans-Joachim Riechers' presentation. "To be right is not worth anything if the information does not address the basic and simple questions of the public!" With vivid examples he showed where and how communication went wrong in the past and how the German EMO member IWM is learning from these lessons. "The protection of the environment is a key issue in European politics and a particular concern for the public. Since both politics and the public make the industry responsible for ensuring a clean and healthy environment, let us take the lead before others take it for us!"

The conference following the opening speeches gave technical and business experts a platform to present recent technological and product develop-

2 Gala dinner at Casa do Alentejo, Lisbon/Portugal

ments as well as market trends and challenges. The variety of topics addressed by 30 papers was very extensive and the parallel sessions well attended. Despite the tight schedule of presentations, speakers and participants took the opportunity to exchange and network – last but not least at the gala dinner at the historic and impressive venue Casa do Alentejo.

The congress on Friday, 22.05.2015, with selected speakers returned to the environmental challenges and was dedicated to the main theme "Moving Towards a Circular Economy". José Inácio Faria, Portuguese Member of the European Parliament, presented his views on the circular economy underlining the challenges related to resource design and efficiency policies for countries and industries which still need to embrace a stronger model of circular economy. Following the presentation by Beatriz Marques about a project called "Shared Waste Solution" which tries to bring together producers of potential waste and users who may be able to utilize it as secondary material, MEP Faria was "thrilled to see how countries like Portugal embrace Circular Economy policies as an opportunity for new business and jobs."

Jose Blanco from the European Demolition Association (EDA) highlighted some of the issues of this industry, underlining that end-of-life considerations need to become an integral part of design and installation of construction products. Luis Silva, Chairman of the EMO Technical Committee, concluded the congress with a presentation showing today's contribution of the mortar industry to resource efficiency and the circular economy leaving no doubt that despite the challenges that lie ahead, the industry has long been part of the solution.

www.mortarsummit.eu

3 Some of the speakers at the congress. Left to right: MEP Jose Ignacio Faria, Carlos Duarte, Beatriz Marques, Luis Silva

DEUTSCHE BAUCHEMIE E.V.

New Board of Management elected

All: Deutsche Bauchemie e.V.

1 The newly elected Deutsche Bauchemie Board of Management (from right): Johann J. Köster, Dr. Erhard Jacobi, Thorsten Schneider, Dr. Christoph Riemer, Dr.-Ing. Claus-Michael Müller, Dr. Josef Weichmann, Dr. Christoph Hahner, Jan-Karsten Meier, Dirk Sieverding, Joachim Straub, Andreas Wilbrand and General Manager Norbert Schröter (not shown on this photo: Dr. Rüdiger Oberste-Padberg)

During its 67th annual conference, convening in Hamburg/Germany on 25.06.2015, Deutsche Bauchemie, the German building chemicals industry association, elected its new Board of Management, awarded its Science Medal and two promotion prizes, and also announced the upcoming expansion of networking activities for the industry in Berlin.

The board elections, held every two years, confirmed the three-person management body currently presiding: Johann J. Köster (Köster Bauchemie AG) remains chairman; his deputies continue to be Dr. Christoph Riemer (Wacker Chemie AG) and Joachim Straub (Sika Deutschland GmbH). New members elected to the board are Andreas Wilbrand (Sopro Bauchemie GmbH) and Dr. Christoph Hahner (DAW SE).

Other board members include: Dr. Erhard Jacobi (CTP Chemicals and Technologies for Polymers GmbH), Jan-Karsten Meier (StoCretec GmbH), Dr.-Ing. Claus-Michael Müller (MC-Bauchemie GmbH & Co.), Dr. Rüdiger Oberste-Padtberg (Ardex GmbH), Thorsten Schneider (Henkel AG & Co. KGaA), Dirk Sieverding (Remmers Baustofftechnik GmbH) and Dr. Josef Weichmann (PCI Augsburg GmbH).

Among other topics, Chairman Johann J. Köster emphasised in his address to the around 130 conference participants the ever more important networking of the industrial association, both nationally and internationally. Now that Deutsche Bauchemie has taken this step at European level, with the setting-up of its own office in Brussels, the intention is to also become more active in Berlin: Köster announced the premiere of the "Building Chemicals Industry Forum" for this autumn, a dialogue event with high-ranking speakers and participants to be held at the Technical University (TU) of Berlin with representatives from the world of politics, the authorities and technical institutions attending. "We sincerely hope that we will be able to establish this meeting as a regular event with high content quality in the German capital", Köster continued, on the industry forum. General Manager Norbert Schröter was also honoured for his 25 years of service.

Also recurring every two years is the presentation by Deutsche Bauchemie of its long established awards for highly qualified up-and-coming personnel in this industry: the Deutsche Bauchemie Scientific Medal 2015, worth 4000 €, was awarded to Dr. rer. nat. Stefan Matthias Baueregger for his doctoral thesis on the "Interaction of latex polymers with cement-based building materials". A 2000 € promotion prize was awarded to each of two recipients, Luise Göbel, M.Sc., for her Master's thesis, "Complexing of calcium ions in cement paste pore fluid using polyvinyl alcohol" and Christina Krämer (M.Sc.) for her Master's thesis, "Investigations into the modification and incorporation of three-phase foams in foamed concrete".

The annual conference's papers section offered an interesting selection of topics, drawn from politics, corporate management and science: Dr. Berend Diekmann (Head of Department VA1 at the Federal Economics Ministry) reported on the fundamentals of, hindrances to and current status of negotiations on the TTIP free-trade treaty, in which he himself is intensively involved. The subsequent discussion generated a clearly positive signal to the participants, and the desire for a successful conclusion, in view of the many bilateral relations existing between and with Deutsche Bauchemie member companies. Torsten Voß, Head of the Hamburg State Authority for the Protection of the Constitution, spoke on the dangers presented by electronic and human industrial espionage, and how companies can protect themselves against it. Prof. Dr. Andreas Rödder (University of Mainz) discussed in conclusion "the German problem in Europe – between self-image and outside perception" – a subject currently of great topicality, in view of Germany's present role in Europe, and with interesting historical dimensions.

www.deutsche-bauchemie.de

2 The hosts and speakers at Deutsche Bauchemie's annual conference (from right): Johann J. Köster (Chairman of the Board of Management), Prof. Dr. Andreas Rödder, Dr. Berend Diekmann, Torsten Voß and Norbert Schröter (General Manager)

SAVETO/LAHTI

Combined forces in the Middle East

All: Lahti

Lahti fluidization hose transport to packing and bulk loading

1 Introducing Saudi Vetonit Co. Ltd.

In 1981, Saudi Vetonit Co. Ltd. (Saveto) was established as a Saudi European joint venture, in partnership with the leading manufacturers of building finishing materials and specialty chemicals in northern Europe. In 1991, the Rashed Al Rashed Group assumed full ownership of Saveto, becoming the first Saudi company to offer a full range of advanced construction chemicals and building materials to the Middle East and North African markets (MENA region) under Saveto & Vetonit brands.

The Saveto Group provides services in the construction market in three business segments:

» A. The projects division
» Saveto provides various technical services free of charge such as specifications support, site supervision, technical submittals, site samples and demos.
» B. The Vetonit retail division
» Saudi Vetonit serves 3000+ retail outlets in Saudi alone. This wide network covers the whole of Saudi Arabia making Saveto's product available instantly to the masses.
» C. Saveto plasters division
» Saveto is the first supplier in the Kingdom of Saudi Arabia to provide bulk supply of plaster products to projects with a complete end to end support of products, equipment and machinery as well as logistical support. The advanced plaster systems provided by Saveto increase efficiency, decrease waste at the same time being green low VOC products.

With these three core business segments Saveto offers a large variety of products in service of the construction industry. These products are distributed in these groups:

» Concrete grouts, repair and enhancement products
» Flooring and coating systems
» Wall and façade systems
» Civil sealants and joints
» Waterproofing
» Plasters and renders
» Putties and finishes
» Tiling systems
» Specialty products
» Primers and ancillary products

The product groups contain many subgroups covering all aspects and core requirements of civil work contractors in both sub-structures as well as superstructures providing end to end solutions. While companies look at product segmentations from a single viewpoint, Saveto with the customer always in mind also segments product usage based on the industry, providing solutions in a carefully segmented customer focus: Buildings, Industrial, Infrastructure etc.

Saveto works on continuous evolution of R&D work as well as literature creation in accordance with international standards and cooperation with international organizations. The company is a member of different associations and owns a R&D center in Saudi where the facilities available to Saveto are state of the art and the most advanced in the Middle East.

The widespread presence of Saveto products in the MENA region enhances the experience with different environmental and climate conditions which allows the company's R&D professionals to develop products catering to each country's specific needs.

2 Manufacturing capabilities

Saveto boasts state-of-the-art manufacturing technologies operating 14 factories in the MENA region:

» Nine factories in the Kingdom of Saudi Arabia (six in Riyadh, one in Jeddah, one in Dammam and one in Rabigh)

Lahti hopper scale

Lahti twin shat mixer

- Two factories in Egypt (in 10th of Ramadan City and in Sadat City)
- Two factories in the United Arab Emirates (in Abu Dhabi and in Dubai)
- One factory in Jordan

All of these are strategically located in industrial areas where all facilities are readily available in addition to being in the close vicinity of major Saveto-owned logistical centers that operate extensive distribution and delivery networks. Saveto has three main regional logistical hubs and an additional 16 centers being fed from the main three hubs.

3 Lahti Precision

Lahti Precision has been Saveto's business partner for the drymix products, since the early days. The Finnish company is an expert for weighing and dosing, handling of bulk materials, and in related automation, plus a forerunner in the drymix business. Lahti Precision has delivered plants for the industrial production of plasters, mortars and other drymix products all over the world. The company supplies total plant projects and related services from engineering to commissioning. Lahti Precision also has long experience and extensive know-how of drymix product technology for various climate conditions.

The company's know-how covers the whole business chain from market evaluation and design of the suitable product range to the marketing of the final drymix products:

- Raw material analysis and development of competitive products
- Drying, crushing and screening systems
- Dosing, weighing, mixing systems and components
- Control systems and components
- Plant modernizations and control system upgrades
- Wide range of services

www.saveto.com
lahtiprecision.com

The Russian drymix mortar industry aims at producing high-quality products to meet the growing demands of the construction industry. AML Anlagentechnik GmbH & Co. KG was approached with the task to design a drymix mortar plant in Sverdlovsk Oblast, in the Ural region, and furthermore to deliver the machine technology.

TEXT **Dipl.-Ing. Matthias Leeke,** Managing Director, AML Anlagentechnik GmbH & Co. KG, Schkopau/Germany

Mixing tower of the new Russian mixing plant

AML ANLAGENTECHNIK

Energy-efficient plants for the production of high-quality drymix mortar in Russia

1 Introduction

AML Anlagentechnik GmbH & Co. KG, located in Schkopau near Halle (Saale), has developed into a renowned and internationally active engineering firm within the drymix mortar industry since its foundation in 2000. In addition to the design and delivery of drymix mortar plants, AML is also a specialized company in the area of dust extraction technology. AML is particularly present in Russia, where it has engineered and constructed plants for a number of well-known drymix mortar manufacturers.

In 2013, the company Kreps approached AML with the task to design a drymix mortar plant in the Sverdlovsk Oblast, in the Ural region, and furthermore to deliver the machine technology.

2 Project description

2.1 Scope definition

The scope of work consisted of the following points:

» Production of all the dry building materials, cement and gypsum based. These are mortars, ranging from renders, plasters, adhesive and screeds to self-levelling compounds, which conform to the entire palette of the drymix mortar products.

» The plant should include the central mixing tower, the sand drying and screening area, as well as the filling of valve sacks and bulk loading into tanker trucks.

» The production capacity of the plant is to be 40 t/h in valve bags and 50 t/h via bulk loading.

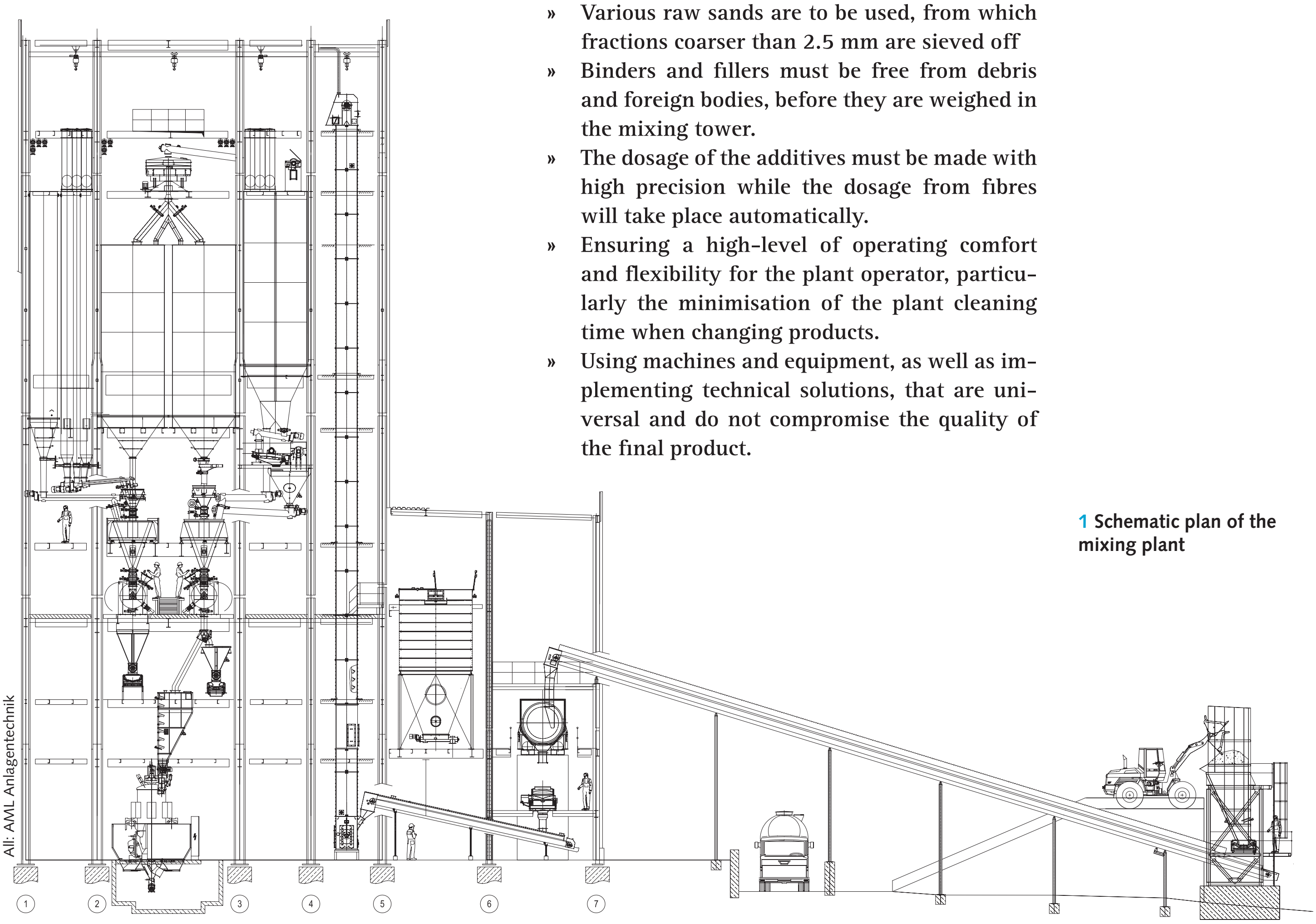
» Various raw sands are to be used, from which fractions coarser than 2.5 mm are sieved off

» Binders and fillers must be free from debris and foreign bodies, before they are weighed in the mixing tower.

» The dosage of the additives must be made with high precision while the dosage from fibres will take place automatically.

» Ensuring a high-level of operating comfort and flexibility for the plant operator, particularly the minimisation of the plant cleaning time when changing products.

» Using machines and equipment, as well as implementing technical solutions, that are universal and do not compromise the quality of the final product.



All: AML Anlagentechnik

1 Schematic plan of the mixing plant

» The planning of the machine technology has to be made aiming to achieve the best possible energy efficiency.
» The plant has to offer the possibility to incorporate a second mixing line at a later stage, therefore doubling the output of the plant.

2.2 General conditions

The Russian drymix mortar industry aims at producing high-quality products to meet the growing demands of the construction industry. However, they face the problem that the raw materials, especially binders and fillers, are often of variable quality and contain debris. Besides that, there are major logistical challenges to guarantee the operation of the plant. These are, in particular, the long transport routes resulting in extended delivery times. Consequentially there is the need for larger storage facilities due to higher quantity requirements of these raw materials.

2 Mixing tower during construction

3 Implementation of the project

3.1 The general outline of the plant

The fundamental principle of the plant is the known mixing tower. Inside the tower, there are 16 silos for the major components and 16 silos for the additives. In the first extension stage of the plant, the weighing of the raw materials is carried out on two main component scales, two additive scales and one volumetric metering device for lightweight materials. Moreover, it also includes a fibre scale as well as a manual feeding system. The effective volume of the mixer is 1700 litres, which, depending on the bulk density of the product, delivers an output of 30 t/h to 50 t/h (Fig. 1).

3.2 Energy efficiency

Taking into consideration the principles of energy efficiency results in the mixing tower design configuration. The raw materials are transported in storage silos and subsequently go through the entire plant from the top down. Under this construction principle, the consecutive material uplifting is largely avoided resulting in a lower energy requirement. Using this kind of tower construction principle, the installation height of the silos reaches a 20 to 25 m mark.

In addition to the mixing tower principle, energy efficiency is achieved through a combination of individual actions that add up to relevant energy savings. These energy saving measures can be found throughout the entire plant. Moreover, they must go along with user friendliness and flexibility of production. Some examples of energy saving measures that have been implemented in the plant are:

» The raw sand is stored in a covered facility designed for a production volume of about four days. During this time, the stored sand is “pre-dried”, as the water drains down through the sand and runs off through the slight slope of the concrete floor. At the same time, the roof above the storage area guarantees that no additional water can pass through precipitation on the storage facility. This would cause an increase of the amount of water to be evaporated with the dryer. More important is this measure in winter, because it prevents snow falling on the raw sand. This snow will need to be defrosted in the dryer, turning it into water, that can later be evaporated. To evaporate only 1 kg of water with an inlet temperature of 0 °C an additional 0.11 kW are needed when compared to the energy needed to evaporate the same amount of water starting at room temperature. This translates into a dramatic increase of the amount of energy needed for drying sand and simultaneously in a decrease of the capacity of the dryer.

» The sand fractions are distributed into the weighing hoppers with a sand dosing system. This system consists of a pneumatic slide gate and a butterfly valve, and replaces the need for a screw conveyor. This results in an especially high economisation effect in comparison to sand dosing with screw conveyors, which requires very high drive power. This alone saves up to 22 kW of installed power for each sand fraction, depending on the design of the conveyor.

» The filter model series, constructed by AML and in use for the last 15 years, distinguish themselves with their exceptionally low-pressure difference during several years of operation time. This is reached through the use of an upstream mechanical separation system integrated into the filter casings and, furthermore, through the use of high-efficiency compact filter elements. This ensures that the AML dedusting equipment works at a differential pressure of 10–12 mbar and therefore a reduction of the fan drive power up to 50 %.

» The whole compressed air supply of the plant works with frequency controlled compressors. This benefits the durability of the plant, but even more, the energy consumption in part-load range operation.

3.3 Sand plant

The sand plant has special features to accommodate not only customer wishes but also the particular climatic environment. The design of the wet sand hopper is strongly influenced by the geographic location of the plant and the aforementioned climatic conditions. In spite of the continental climate the region shows a high temperature variation ($\Delta T = 75\,°C$). The winter can last up to 6 months and reach temperatures as low as −40 °C. Due to this AML not only decided to use the time-proven discharging aids but also designed a trace heating system to guarantee a smooth and reliable transport of the wet sand, even during the Russian winter.

The wet sand hopper consists of two chambers as a result of using raw sands from different sources. This way, the frequency-controlled discharge conveyors can premix the raw sands according to the production requirements. In addition to the improved product quality this also results in an equalisation of the fluctuating qualities of the raw materials and, furthermore, in a faster reactivity to current filling levels.

The dryer-cooler is followed by a policing screen, which eliminates the oversize grains as well as any foreign bodies. This not only protects the following equipment, but also relieves them of any unnecessary loads.

The screen for separating the sand fractions has been chosen deliberately for its compact design. Centring it right on top of the lowered sand silos results in savings not only of tower height but also of conveying height and required power.

3.4 Screening of binders and fillers

One of the biggest challenges for the Russian producers of dry building materials is the large fluctuation in quality of the raw materials and the large amount of included foreign bodies. AML Anlagentechnik GmbH & Co. KG was able to solve this problem with the help of appropriate machine technology. For each raw material, a policing screen is located before the main weighing hoppers. Continuously loaded by screw conveyors, each one of the screens eliminates all debris from

3 Weighing system

the raw material. Freed from any foreign bodies and unwanted oversized grains, the raw materials are stored in technological hoppers and afterwards dosed into the main weighing hopper via screw conveyors. The use of this method is indispensable for the production of finer products like fillers, grout and adhesives.

These measurements guarantee a constant product quality and minimize the potential risk of complaints. Only a few oversized grains in a bag of tile adhesive results in product recall of the entire delivery.

3.5 Dosing of additives and fibres

It is commonly known that the most important demand in additive dosage is "Accuracy, accuracy, accuracy!" However, it is always presumed that the speed of the process is fast enough. On the one hand, the additive dosing systems dictate the production output of the entire drymix mortar plant with their dosing efficiency. On the other hand, their dosing accuracy significantly determinates the quality of every product. To achieve both AML Anlagentechnik GmbH & Co. KG uses additive dosing screw conveyors with the standardised diameter of 139 mm and an additional high precision dosing unit. The high precision unit, a screw conveyor with a diameter of 50 mm, is responsible for the accurate dosing of the last 10-15 % of the required additive amount as specified in the mixing recipe. The dosing accuracy is highly increased by the standardised use of frequency converters and the additional high precision dosing unit. In spite of the high production output dosing accuracies of a few grams are still reached. A control system with adaptive dosing logarithms, e.g. an automated dosing lag correction, should be seen as state of the art.

3.6 Fibre dosing

The fibre material is stored in silos with high-angled cones and the necessary discharge aids to reduce the side and inner friction. Additionally the cones are equipped with an integrated agitator to guarantee an optimized flow into the subsequent fibre screw conveyor. As a matter of course, the storage and dosing, as well as the weighing and transport, are custom-made for each fibre material. It became apparent that the different fibre types have highly different flow and storage characteristics. Therefore the selection of the right system is of essential importance. In this case, the dosing goes into a separately installed fibre-weighing hopper. A pneumatic conveyor with a combined suction-pressure-system carries out the filling of the mixer.

3.7 Extension with second mixing line

With its future orientated design, this plant can be upgraded with a second mixing line. With this extension, the customer is not only able to double the plant output but also to increase the quality of the products immensely through separation of grey and white products. This way of increasing the production capacity, namely through optimising the use of the equipment on the one hand, and a compact plant design on the other, is not only energetically efficient but also optimises the investment.

3.8 Plant control

The complete mixing plant has a control system which automates and documents all processes. The centrally placed Siemens PLC uses decentralized control cabinets connected via bus system. All production data is saved on a server and is easily accessible when needed. The user access to the control system, the data and the parameters is carried out through corresponding access authorisations in order to avoid misuse. For a modern production plant such a control system is an unavoidable tool of quality assurance. In the case of maintenance or other special situations, the plant can be operated in a semi-automatic or even manual mode. Maintenance modules, for example drive unit run-times, assist the operator and therefore ensure the functionality of the plant. Furthermore, it is a key parameter in maintaining the low energy consumption of the plant.

4 Summary

In close cooperation with the customer, AML Anlagentechnik GmbH & Co.KG fulfilled all additional constructional and procedural-related requirements that exceeded the ordinary mixing tower design. The result is a highly flexible production plant for a vast variety of products. Alongside the basic engineering AML also handled the detail engineering for the electrical cable routes, the pneumatic conveying lines, compressed air pipes and the complete project work in the country's language.

This project shows the ability to combine the standards with special purpose solutions and the customer-orientated project work. The described plant is currently being assembled. The commission will start this fall.

Some of the described methods are based on a vast experience and detailed examination. Nevertheless, many measures are partially trivial and basic. That may be the reason why they are sometimes not even taken into consideration, but this can easily increase operational costs into a double-digit percent range.

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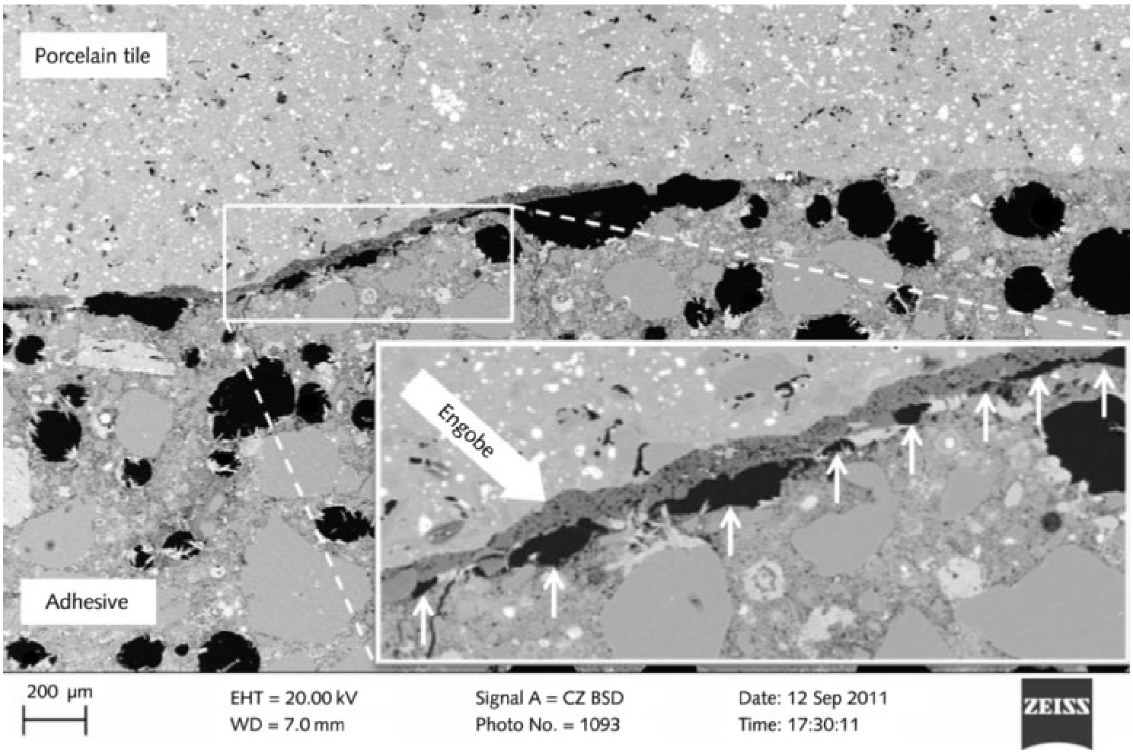


Interface between porcelain stoneware and floating layer of a tile adhesive. The additional air inclusions (black voids, marked with arrows in the enlarged detail) can be seen in the area of the tile coating (engobe in the left half of the picture). Where there is no engobe (right half of the picture) the adhesive is fully bonded to the tile (Note: the engobe appears dark in the backscatter electron picture)

All: Akzo Nobel Chemicals AG

It is generally known that the buttering-floating method promises better adhesion. But why is this actually so? The following article describes six advantages of the combined method and explains the background.

TEXT **Dr. Roger Zurbriggen,** Akzo Nobel Chemicals AG, Sempach Station/Switzerland
Karsten Pass, Akzo Nobel Functional Chemicals GmbH, Frankfurt/Germany;
now at: Sakret Trockenbaustoffe Sachsen GmbH & Co. KG, Claussnitz/Germany

AKZO NOBEL

Buttering to be on the safe side – six material technology advantages of buttering*

1 Introduction

Two very different material surfaces come into contact when a porcelain tile is placed by the floating method. On one side there is the previously combed mortar that forms a thin dry skin with increasing exposure time (time between mortar trowelling and embedding of the tile) and reduces the wettability of the mortar surface. On the other side is the rear side of the tile manufactured in the factory that may be covered with chalky coatings or other forms of dust that can act as separating agents. If these two material surfaces are to form a durable bond then optimum wetting and a contact layer that is as free as possible from voids are required. This can be achieved by the use of flow-bed mortars with a long workability time or the combined buttering-floating method. In either case a short exposure time is an advantage because this avoids formation of skin that reduces adhesion.

The combined method was already described in 1979 in DIN 18157 (Part 1, Section 7.3.3) and since then has been applied unchanged, especially for thin-bed mortars for wall applications.

According to this standard the thin-bed mortar is applied in two operations. A thin contact layer (also called scratch layer) is applied first with a smoothing trowel. In a second operation thin-bed mortar is combed on top of this contact layer. This applies to the floating, the buttering and the combined buttering-floating processes. In the latter case the rear side of the tile is, in practice, often only covered with a contact layer without then combing the thin-bed mortar. However, just this contact layer [1], always supposing, of course, that it does not dry before the tile is placed, provides a good precondition for a durable adhesion.

The combined method as described in DIN 18157 requires significantly more mortar and also more working time. Tilers who offer this method often have their prices beaten down and are therefore forced to abandon this more expensive method in favour of lower tiling costs. However, the customers are often not aware that they are giving away material technology advantages and therefore the greater guarantee of durability.

2 The six advantages of the buttering-floating method

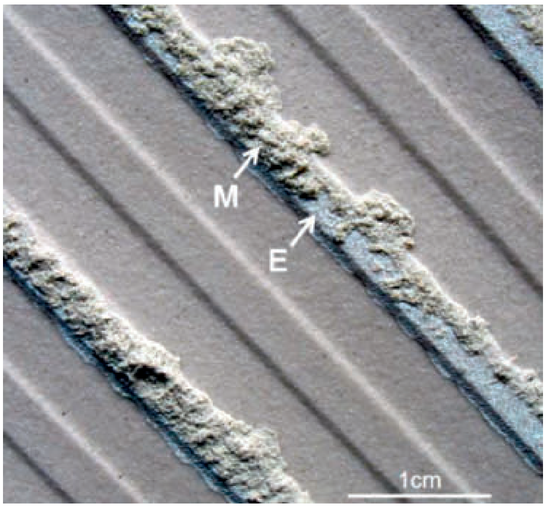
The six material technology advantages that are obtained at the material interface by using the combined buttering-floating placement technique are described below.

2.1 No dusty separating layer

Buttering – or covering the rear side of the tile with a contact layer of mortar – has the effect that any chalky coating or other dust on the rear side of the tile is forcibly incorporated in the contact layer and can therefore no longer act as a separating agent.

2.2 No air inclusions at the interface

Buttering – or covering the rear side of the tile with a contact layer of mortar – produces full bonding of the mortar to the tile without any additional air inclusions at the interface. Especially where there is a coating on the rear side of the tile (also known as "engobe" or "separating agent" [2]) the additional air inclusions in case of the floating method can be considerable and immediately reduce the adhesive strength (leading image).

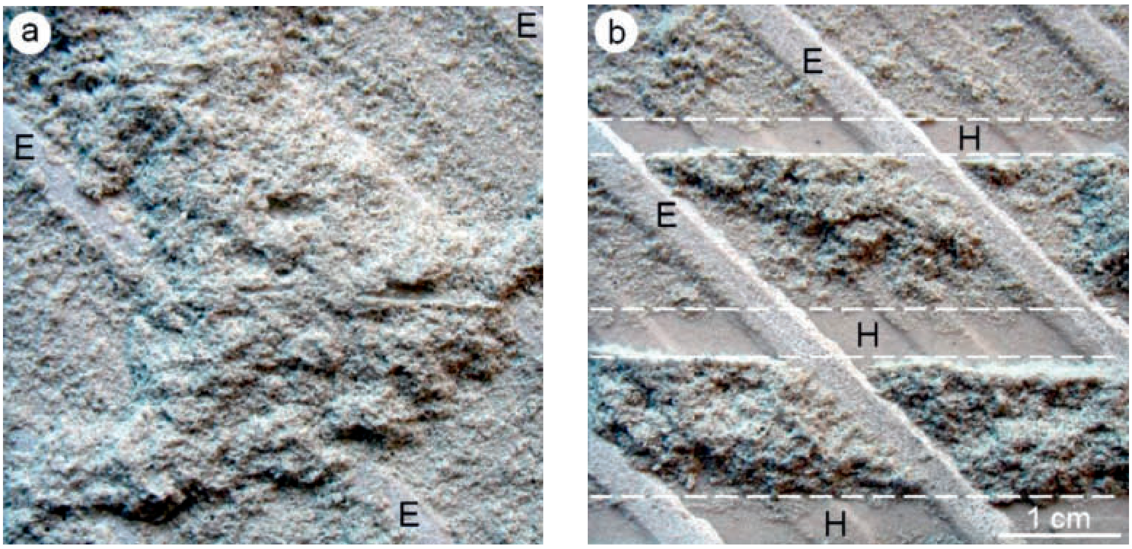


1 Typical example of an engobe acting as an adhesion promoter. Detail of a fracture pattern after an adhesion test (1.7 N/mm²) on a 5 cm x 5 cm test area that was cut from the centre of a 30 cm x 30 cm wall tile (porcelain stoneware) after seven months outdoor exposure. Application was done by the combined method and mortar residues (M; cohesion fracture) are only apparent along the engobe (E)

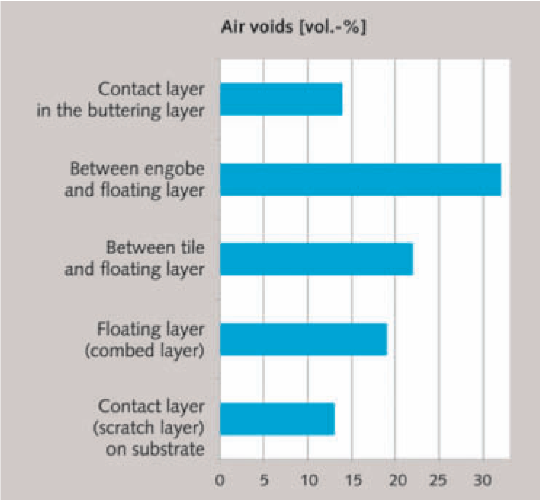
2.3 Engobe can promote adhesion

Buttering – or covering the rear side of the tile with a contact layer of mortar – may, under some circumstances, change the white engobe on the ridges on the rear side of the tile from a separating agent into an adhesion promoter. Fig. 1 shows one such case where the tile had been placed using the combined method. In the subsequent adhesion test a cohesive fracture had only appeared at the coated ridges (engobe) while the fracture pattern between the ridges was of the adhesive type.

If the chalky parts of the engobe – which can function as a separating agent – are incorporated in a contact layer then, due to their porosity, the



2 Fracture pattern after adhesion test on 5 cm x 5 cm test area that was cut from the centre of a 30 cm x 30 cm wall tile (porcelain stoneware) after 33 months outdoor exposure. (a) Applied by the combined method, 2.1 N/mm², cohesion fracture. (b) Applied by the floating method, 1.6 N/mm², adhesion fractures at the engobe (E) with cohesion fractures in between. Hollows (generated by toothed trowel) are marked with an H



3 Change in air void content in the different layers of the adhesive and at the interface, depending on the application method

sintered parts of the engobe can become docking sites for the adhesive mortar. (The many small black voids within the engobe can be seen in the enlarged detail in the leading image). This is clearly apparent from the cohesive fracture along these coated ridges in an adhesive test (Figures 1 and 2) [3]. These findings also coincide with the conclusion drawn by Henke [2] that "If the engobe is closely attached to the rear side of the tile then there is nothing to prevent a good adhesive bond. Care is required if the engobe appears as a chalky powder acting as a separating agent."

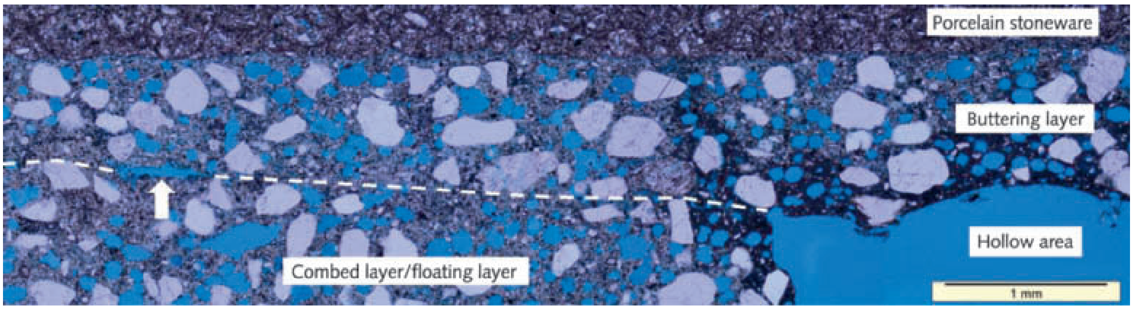
2.4 Compacted contact layer

The buttering layer, specifically the layer that is applied directly to the rear side of the tile, appears under the transmitted light microscope as a compacted contact layer with a significantly lower proportion of air voids, which increases the strength. The combed mortar (floating layer) has an air void content of 19 vol.-%. However, a compacted microstructure with a significantly reduced air-void content of only 13-14 vol.-% was found in the contact layer on the substrate and in the contact layer on the tile (Fig. 3). Without buttering, or without a contact layer on the rear side of the tile, air can also be trapped at the interface when the tile is placed. The air content can rise to 22 vol.-% at uncoated sites (without engobe), but at coated sites (engobe) the additional air entrapment at the interface can reach a total air void content of 32 vol.-% (see also the leading image). This obviously causes an immediate loss of adhesive strength.

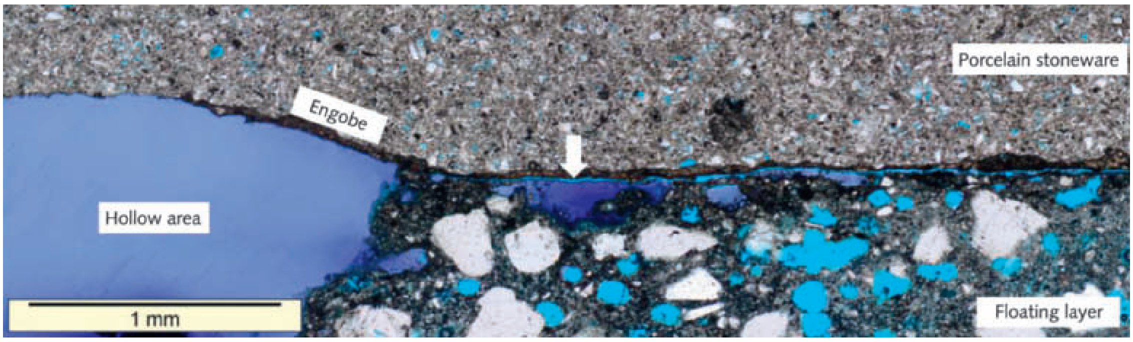
It should be mentioned here that in all these investigations the exposure times for the 30 cm x 30 cm porcelain tiles was less than five minutes. This means that on the building site, where longer exposure times and also hot, dry and windy conditions may prevail, such effects become even more important. Among other things, this can have the effect that the adhesive bond is only locally achieved, resulting in failure [4].

2.5 No skin at the interface

The skin that forms on the surface of the combed floating layer does not come into contact with the dry tile but with the wet buttering layer where it can be resorbed. If it does remain then at worst it only weakens the mortar cohesion but not the much more critical mortar adhesion at the interface with the tile (Fig. 4).



4 Resorbed shred of skin (arrow) at the boundary between combed layer and buttering layer (voids coloured blue; light microscopy on thin section)



5 Adhesion crack (arrow) starting from a hollow area that had been impregnated with dark-blue resin at the building site. The light-blue resin was impregnated under vacuum by the assistant in the laboratory and fills the air voids in the adhesive

2.6 No hollow areas at the interface

The buttering procedure prevents that hollows (caused by the toothed trowel) are in direct contact to the tile interface. Stress calculations have shown that in the edges of hollows appear stress peaks [5]. If these hollows are in direct contact to the tile (without buttering) then the stress peaks at their edges can lead to adhesion cracking. (Fig. 5).

3 Conclusion

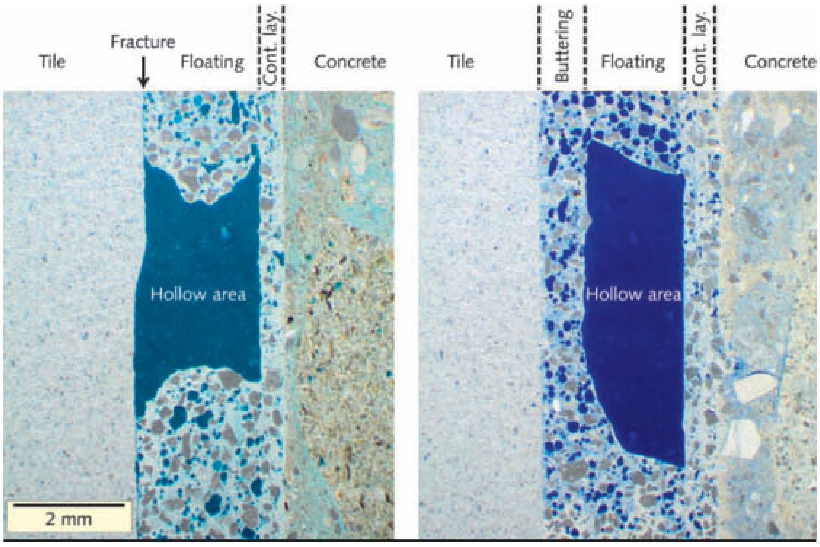
Pass et al. [5] have shown how hollows in the combed layer can cause stress peaks. Alongside the direct loss of bond area this is a second reason for avoiding these voids. Modern flow-bed adhesives take this into account and permit a hollow poor/free embedding of the tiles. If these flow-bed adhesives also have an extended open time then the formation of skin is also delayed and good wetting is ensured. However, this still means that the tiler must always keep an eye on this skin formation under the actual site conditions and aim for the shortest possible exposure times.

Even more security can be obtained by covering the rear side of the tile with a contact layer of the flow-bed mortar. This then bears all the advantages of a compact contact layer (see above) combined with the advantages of a hollow free/poor embedding of the tiles. This procedure is recommended by the mortar producers particularly for large formats or for high performance applications.

Finally, Figure 6 shows once again a comparison of the microstructures resulting from the two methods of application (left: floating method, right: buttering-floating method). The buttering layer, i.e. the contact layer, appears as a compact, fully bonded layer that visualises how this type of microstructure can achieve durability.

The combined buttering-floating method takes more material and time, and therefore means higher application costs, but material science studies, like this one, show that this investment is much lower than the financial risks that would be entailed by making savings in the implementation. It is therefore worth explaining this aspect to architects, employers and owners so that the financial arguments can be countered by material technology facts and reduce the attempt to make negligible savings in the tiling work at the expense of quality with a high risk for cost intensive repair works.
Among other things, the following should be borne in mind when applying high performing tilings:

- » Use modern flow-bed mortars with good open times, especially for porcelain stoneware
- » Stick to the manufacturer's instructions
- » Unless specifically recommended otherwise, use the combined method and cover the rear side of the tile with a layer of mortar
- » Adhere to the application obligations: keep an eye on skin formation by the finger test, choose appropriate maximum exposure times and every now and then evaluate full wetting by removing a tile.



6 Thin section with blue-coloured hollow areas and air voids. Application by the floating method on the left. Note the adhesion crack starting at the edge of the hollow. Application by the combined buttering-floating method on the right

Acknowledgements

We would like to thank Alexander Wetzel, Bern University, Lukas Huwiler, Monika Stocker and Roland Bachmann, Akzo Nobel Chemicals AG, for their support during the field and laboratory work. Frank Gfeller, Bern University, carried out the statistic scoring on the thin sections. Thanks are also due to Sebastian Dettmar of Dettmar dissection Technology GmbH & Co KG, Bochum, for preparing the thin sections.

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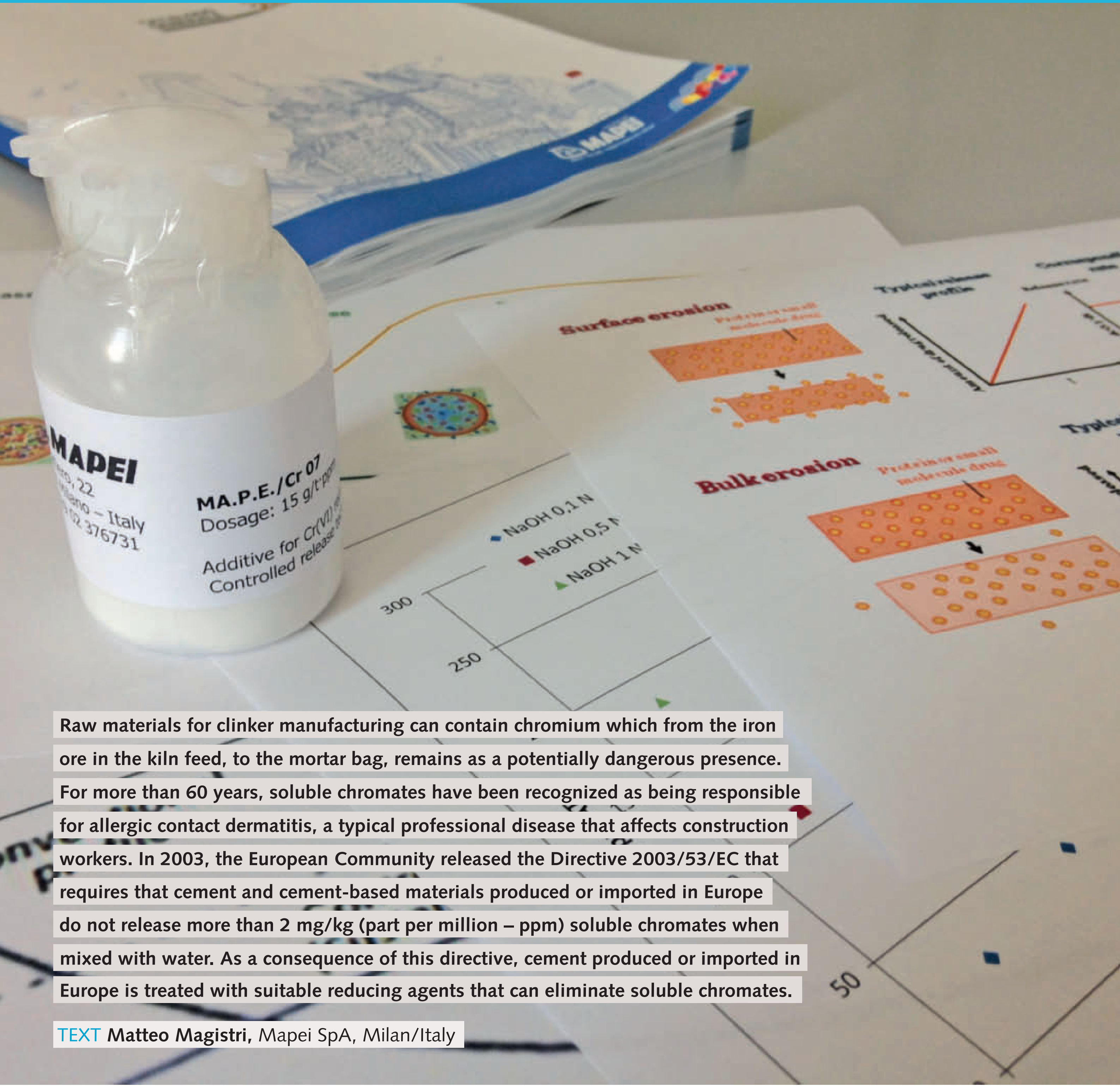


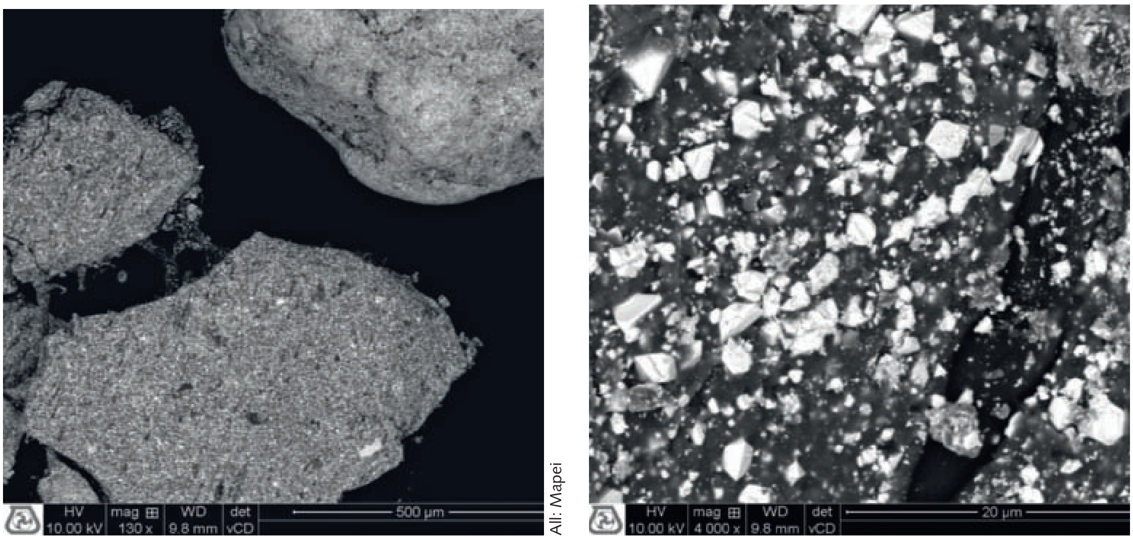
Raw materials for clinker manufacturing can contain chromium which from the iron ore in the kiln feed, to the mortar bag, remains as a potentially dangerous presence. For more than 60 years, soluble chromates have been recognized as being responsible for allergic contact dermatitis, a typical professional disease that affects construction workers. In 2003, the European Community released the Directive 2003/53/EC that requires that cement and cement-based materials produced or imported in Europe do not release more than 2 mg/kg (part per million – ppm) soluble chromates when mixed with water. As a consequence of this directive, cement produced or imported in Europe is treated with suitable reducing agents that can eliminate soluble chromates.

TEXT **Matteo Magistri,** Mapei SpA, Milan/Italy

MA.P.E./Cr07: a new reducing agent for ready-mix mortars

MAPEI

Encapsulation and controlled release of Cr(VI) reducing agent: application in ready-mix mortars



All: Mapei

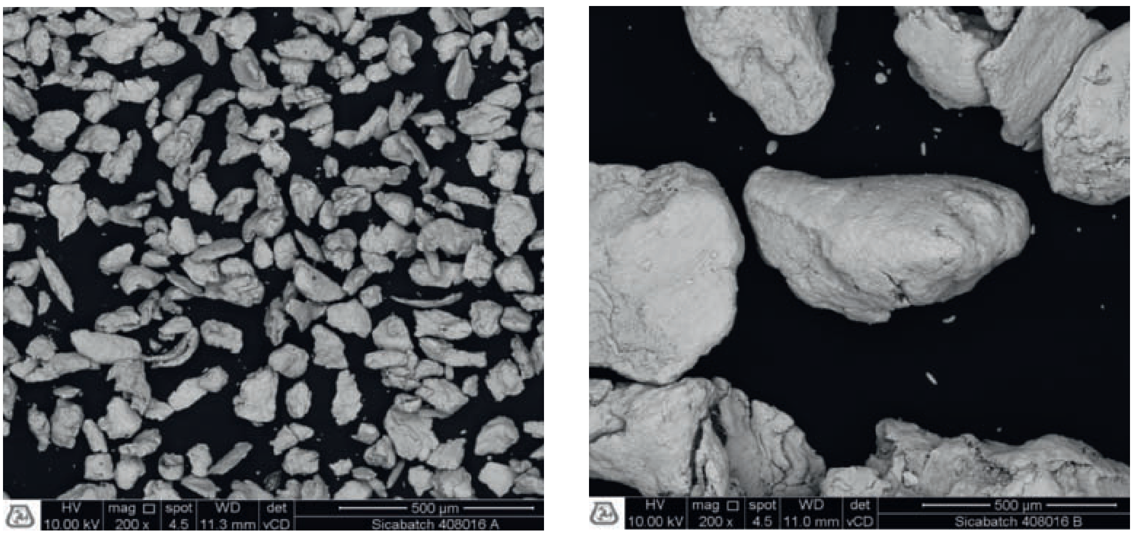
1 a and b SEM (Scanning Electronic Microscope) images of a typical additive consisting of encapsulated antimony compound. **1 a** shows a 130 times magnification: particles dimension is around 500 µm. **1 b** shows a much higher magnification (4000 times)

1 Introduction

The manufacturing process of Portland cement is standardized and widely described in several publications [1]. Raw materials (usually limestone and clays, with some aluminium and iron) are quarried (or obtained from the recovery of waste materials), then properly blended and ground in order to prepare the so-called raw mix. This is used as feeding for the pre-heater tower and rotary kiln, where silica and lime (with alumina/iron oxides used as flux) react in a high temperature process to form the calcium silicates that compose the Portland clinker.

Clinker is then finely ground together with gypsum and secondary mineral additions (such as limestone, fly ash, granulated blast furnace slag, natural or artificial pozzolans) in order to obtain the well-known grey powder usually referred to as Portland cement, used by millions of construction workers as hydraulic binder in concrete, mortars, screeds, grouts and many others masonry applications.

Unfortunately, raw materials for clinker manufacturing can contain chromium that, in the highly alkaline and oxidizing conditions of the rotary kiln, is partially converted to hexavalent chromium and fixed as soluble chromate: hence, from the iron ore in the kiln feed, to the mortar bag, chromium remains as a potentially dangerous presence. For more than 60 years [2], soluble chromates have been recognized as being responsible for allergic contact dermatitis, a typical professional disease that affects construction workers. In 2003, the European Community released the Directive 2003/53/EC that requires that cement and cement-based materials produced or imported in Europe do not release more than 2 mg/kg (part per million – ppm) soluble chromates when mixed with water [3]. As a consequence of this directive, cement produced or imported in Europe is treated



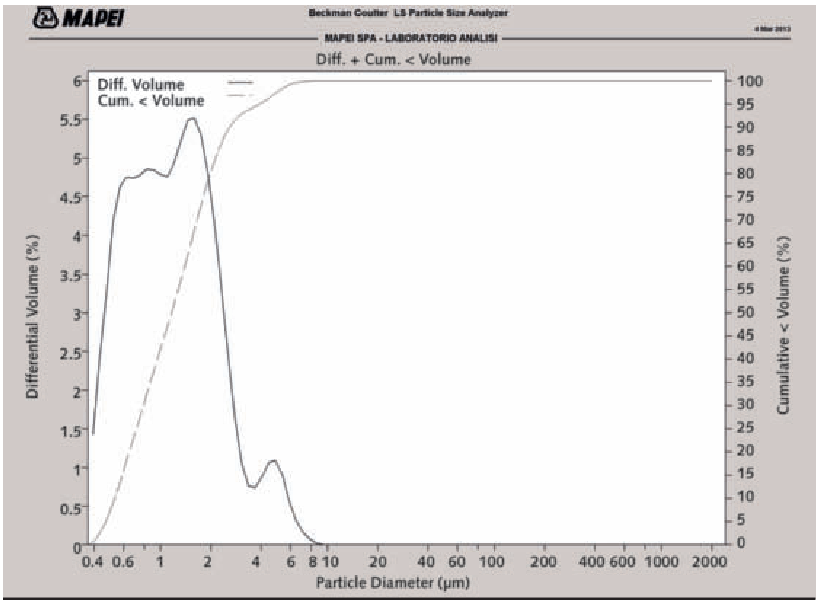
2 a and b Showing a similar product, with a higher content of antimony with suitable reducing agents that can eliminate soluble chromates.

2 Hexavalent chromium in ready-mix mortars

Ready-mix mortars are ready to use, cement-based powder products for several building applications. They are formulated with cement, fine aggregates such as siliceous sands or carbonate and a wide range of additives depending on the properties and use of the mortar: strengths, durability, workability, control of air content, frost resistance, shrinkage/expansion and so on.

Ready-mix mortars are cement-based materials: they can contain soluble chromates that come from the Portland cement used in their formulation. Consequently, they need to be treated for Cr(VI) elimination. In some cases the reducing agent already contained in cement is enough, but quite often a further addition is needed. In fact, in comparison to Portland cements, the reduction of hexavalent chromium in ready-mix mortars could sometimes be a more challenging task:

- » Ready-mix mortars usually have longer shelf lives: consequently, the reduction of soluble chromates should be as long as possible. It is quite common to guarantee at least six months or one year reduction stability. It is a normal practice indeed to sell ready-mix mortars in bags, that are intended to stay on the market for very long periods of time.
- » Ready-mix mortars are hardly used in closed circuit batching operations, as happens sometimes with concrete. Screeds, grouts, renders are required to be handled by workers, who cannot avoid coming into contact with the fresh mix, and being exposed to a higher risk of allergic contact dermatitis.
- » Ready-mix mortars are widely used for applications in which esthetics play a key role: color variation due to staining must carefully avoided.
- » While the addition of reducing agent during cement manufacturing is perfectly feasible with liquid additives, ready-mix mortars are produced by blending different powders, thus requiring a reducing agent in powder form.



3 a Particle size distribution of a typical high fineness antimony compound. All the particles are smaller than 10 µm

As a consequence, a suitable reducing agent for hexavalent chromium in ready-mix mortars should be highly resistant to oxidation and to all degradation phenomena that can reduce its efficacy after prolonged storage. Additionally, it should not promote any staining or variation of the color of hardened surfaces and it must be easy to incorporate during powder blending, even at low dosage.

Antimony compounds, proposed and developed for the reduction of hexavalent chromium in cements [4], certainly possess the aforementioned characteristics of high efficacy and long term reduction and absence of side effects. Unfortunately, the use of antimony compounds in powder form can be potentially dangerous. Several antimony compounds are harmful and the concerns are usually associated with the inhalation of fine dusts. This risk is completely eliminated with the use of liquid formulations from which dust release is impossible, but during blending operations (and in particular during ready-mix mortar preparation) a liquid product would not allow a correct and uniform addition of reducing agent while, on the other hand, the addition of powder antimony compound would leave the risk of dust formation, release and inhalation. This is why, until now, the development of powder products based on antimony has been severely limited.

3 Encapsulation and controlled release technology

Mapei efforts in R&D and the constant cooperation with the main producers of antimony compounds recently succeeded in overcoming this limit by developing the controlled release technology, which consists of the encapsulation of antimony compound in a special polymer: this allows the complete elimination of fine dust and allows the use of this reducing agent in a completely safe way.

The polymer is chosen in order to be quickly soluble in alkaline media (such as cement-based materials gauge water) and, as soon as cement is mixed with water, the antimony compound is released and expresses its full reducing power.

The use of this so-called "encapsulation/controlled release" technology (widely used in the pharmaceutical industry) presents several advantages:

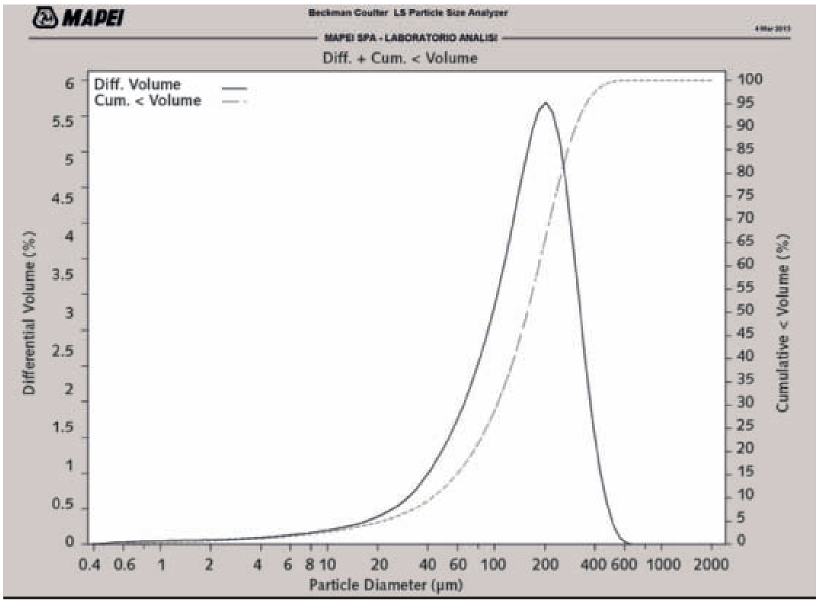
» The antimony compound is completely embedded in the polymer matrix, thus avoiding any possibility of dust release.
» The particle size distribution can be carefully controlled, with total elimination of the finest fraction. Some antimony compounds are very fine (in some cases 100 % particle size distribution is below 10 µm). By producing a suitable encapsulated product, the presence of free antimony is completely eliminated and the finest fractions can be completely cut.
» The possibility of tailor made products in terms of particle size distribution. Depending on the addition point of cement (in the grinding mill, at separator level, in powder blenders, during cement bagging or elsewhere), different particle size distributions may be required, ranging from finer (20-200 µm) to coarser (100-500 µm) ones.

The antimony compound maintains its superior performance, but the risk associated with inhalation is strongly reduced. The particular morphology of encapsulated antimony can be evidenced using advanced microscopy techniques.

Figure 1a and 1b represent SEM (Scanning Electronic Microscope) images of a typical additive consisting of encapsulated antimony compound. In particular, Figure 1a shows a 130 times magnification: the particles dimension is around 500 µm. Figure 1b at a much higher magnification (4000 times) that shows the antimony compound (white crystals, dimensions in the range of a few µm) completely embedded in the polymer matrix (that appears darker). When the polymer comes into contact with alkaline water, it dissolves very quickly releasing the antimony compound.

Figures 2a and 2b show a similar product, with a higher content of antimony. The elimination of finest fractions (and the absence of particles that can be easily inhaled) can be demonstrated by determination of the particle size distribution, through laser diffraction. Particle size distribution is a graph reporting the content of each individual particle size in a powder, in the function of particle diameter.

Figure 3a shows the particle size distribution of a typical high fineness antimony compound. All the particles are smaller than 10 µm: inhalation of such fine particles can be very dangerous due to possibility of reaching the lungs. If this powder is encapsulated in polymer, the final dimension can be carefully controlled and the finest fractions can be removed: Figure 3b shows the particle size distribution of a powder additive based on encapsulation/controlled release technology. Particle dimensions are between 20 and 600 µm and the finest fractions are no longer present.



3b Particle size distribution of a powder additive based on encapsulation/controlled release technology. Particle dimensions are comprised between 20 and 600 µm

4 Conclusions

The controlled release technology based on encapsulation of reducing agents in a polymer matrix can be successfully used in order to prepare innovative additives. In fact, the elimination of soluble chromates in ready-mix mortars is usually harder than in Portland cement, due to stringent requirements of long lasting efficacy: the antimony compounds possess the superior technical performance, but are in some cases difficult or dangerous to handle in powder form. The encapsulation of the antimony compound in a suitable soluble polymer allows maintenance of the performance, strongly reducing the risk.

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Impact of the addition of silane, siloxane or silicone resin-based hydrophobic powders on cement-based drymixes is illustrated. Effect of silicone hydrophobic powder addition on water absorption of cement-based mortar is described as well as the positive impact on deleterious phenomena such as efflorescence or color fading. New silicone resin-based powder is described.

TEXT **Dr. Jean-Paul Lecomte[1], Axel Giesecke[2], Dani Lladó[3], S. Salvati[1]**
[1]Dow Corning Europa SA, Seneffe/Belgium, [2]Dow Corning GmbH, Wiesbaden/Germany,
[3]Nubolia Pigmentos S.L., Barcelona/Spain*

Silicone resin-based hydrophobic powder

DOW CORNING/NUBIOLA

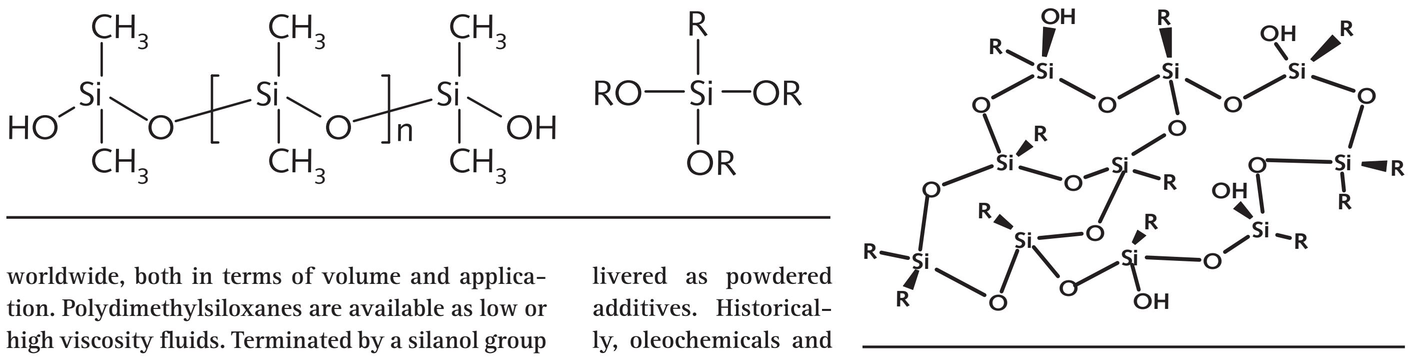
New silicone resin-based hydrophobic powder for the drymix market

1 Introduction

The porous structure of construction materials based on ordinary Portland cement leads to their high sensitivity to capillary water absorption. Control of water absorption is therefore key to reducing various kinds of water-induced damage such as efflorescence, staining, spalling due to freeze-thaw cycles, chemical attack and corrosion to reinforcing steel. A number of solutions have been used in the past to decrease water absorption such as the post-treatment of water repellents or the use of so-called "hydrophobic admixtures" within the cement matrix itself to provide integral water repellency. Siloxane and alkoxysilanes have now become a well-known class of materials used both for post-treatment water repellents [1, 2], admixtures in non-load-bearing concrete [3] or as post-treatment or admixture in fiber-reinforced cement boards [4].

1.1 Siloxane and alkoxy silanes

Silicone is a generic term describing polymers based on a siloxane backbone (based on the repeating unit: Si-O-Si). Polydimethylsiloxanes or PDMS (Fig. 1) are the most common siloxanes used



worldwide, both in terms of volume and application. Polydimethylsiloxanes are available as low or high viscosity fluids. Terminated by a silanol group (Fig. 1), they are reactive. Their low surface tension, better resistance to UV radiation vs. organic polymers and high gas permeability are of great benefit in the field of hydrophobic treatment.

Silanes are molecules based on one silicon atom which bears four substituents. Alkyl trialkoxy silanes (Fig. 1) are used in hydrophobic additives, either for post-treatment or admixture as they have good reactivity towards inorganic, silanol-rich surfaces. The aliphatic chain (i.e. isobutyl or octyl chain) confers the hydrophobic character to the treated substrate. Upon hydrolysis and condensation, silanes create a resinous network which bonds covalently to the surface of treated materials leading to outstanding water resistance durability.

Silicone resins are obtained by a sequence of controlled hydrolysis and condensation reactions of individual or mixtures of silanes (Fig. 1).

Silicone resin with alkoxy groups and hydrophobic alkyl groups can be designed in such a way as to diffuse within the cement matrix and react with the pore's surface. The reaction leads to a chemical anchorage to the treated materials.

It is often the case that the chemicals used as water repellents need to be further formulated to enable their effective use. This additional formulation step will be named here as the delivery system. For example, water repellents can be used as such, diluted in solvent, or emulsified or formulated as powders. The delivery system needs to be adapted to the application method, which can range from the use of emulsions for post treatment water repellents or hydrophobic admixtures into mortar/concrete slurry or silicone hydrophobic powder in drymixes which is the topic of this paper.

1.2 Drymix and development of silicone hydrophobic powders over time

Drymixes cover the range of high performance mortars designed for specific applications ranging from masonry mortar, tile adhesive, grouts, render and skim coats. Amongst these applications, some require protection against water penetration (tile grouts, render, ...) which can be obtained thanks to the use of "integral water repellent" delivered as powdered additives. Historically, oleochemicals and metal soaps were used for that purpose [5]. As water insoluble particles, they act as "pore blockers" which will decrease the gas permeability of the cement matrix. Often, as they are finite hydrophobic particles, they are not evenly distributed within the matrix, leading to poorer or uneven control of efflorescence. This will be illustrated in this paper.

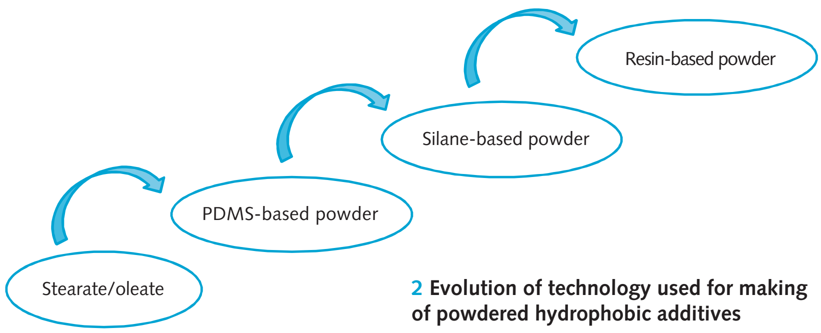
Some difficulty to handle or process metal soaps, the difficulty to wet drymixes modified with them or their lower durability in the cement matrix (poorer weathering) have driven the need to develop new solutions.

In the last 5-10 years, silanes and siloxanes were formulated and transformed from low viscosity liquids to powdered additives in order to be used in drymix formulations as "integral water repellent" [6].

The first silicone hydrophobic powders proposed on the market were based on simple polydimethylsiloxane. Reduced reactivity of silanol ended PDMS led to some improvement requirements.

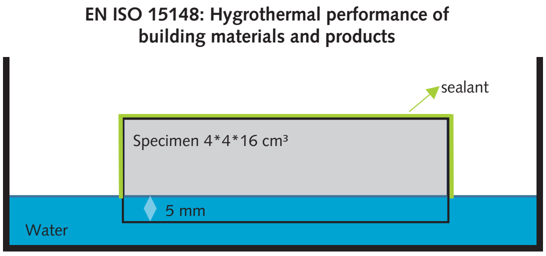
Silicone hydrophobic powder based on silane or a mix of silane and siloxane appeared to significantly improve the "hydrophobic performances" both initially [7] and after ageing [8]. Accelerated ageing studies demonstrated clearly the benefit of silicone hydrophobic powder based partially or entirely on alkyl alkoxy silane. The low impact of the addition of silane on the cement hydration processes [9] associated with the low impact of weathering on hydrophobic performance [8] makes silicon-based powder an additive of choice in modern drymix formulation.

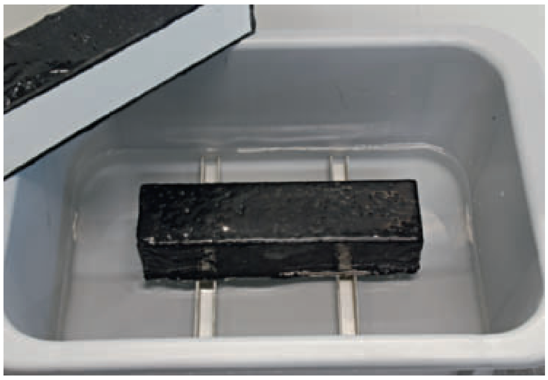
1 Structure of polydimethylsiloxane, alkyl trialkoxysilane and schematic representation of a silicone resin (R can be ethoxy, methoxy, methyl, phenyl or octyl group)



2 Evolution of technology used for making of powdered hydrophobic additives

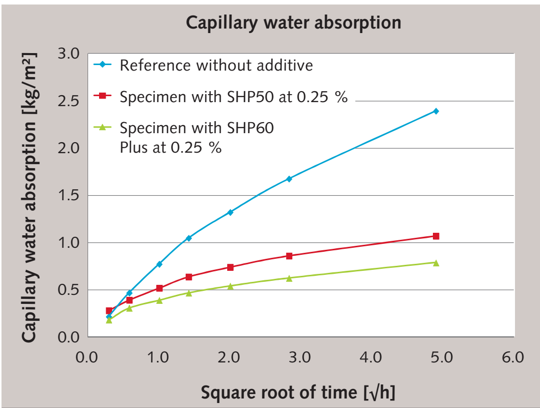
3 Set-up for testing capillary water absorption according to EN ISO 15148





These hydrophobic powders are now commonly used in drymix formulations.

Research on new hydrophobic active materials identified some specific liquid “silicone resins” which provide further improved hydrophobic performance. They are now used to develop new improved hydrophobic powders for the drymix market.



4 Capillary water absorption as a function of contact time with water of reference and modified mortar blocks tested according to the EN ISO 15148 method

This paper concentrates on silicon-based hydrophobic additives formulated as powder. In this document, the phrasing “hydrophobic performance” will describe the extent to which a powdered hydrophober used as admixture in a cementitious matrix can significantly decrease the tendency of the set matrix to absorb water by capillary action.

Transforming a liquid into a powdered additive requires an additional processing step. Simple adsorption of silane/siloxane on fine powder such as silica provides a nice free flowing powder. However, the final powder is highly “hydrophobic” and does not mix easily with water. This difficult dispersion in water will lead to uneven distribution in the mortar mix and to uneven control of efflorescence.

Different technologies are now used to formulate liquid hydrophobers into powdered additives, while enabling their easy dispersion into the mortar slurry. Technologies such as spray drying or size enlargement/granulation are now commonly used.

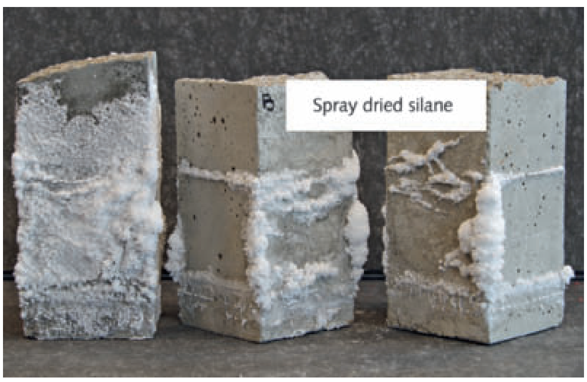
Some benefits obtained thanks to the addition silicone hydrophobic powders are illustrated hereafter.

2 Performance of silicone resin-based hydrophobic powders

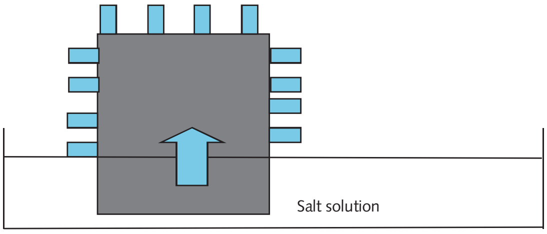
2.1 Impact of silicone hydrophobic powders on mortar behavior

Mortars were prepared according to EN 196-1 and tested to assess the rate of setting (by the Vicat needle method), consistency (by the penetration method), air content and mechanical properties.

Results will not be illustrated here but it can be said that addition of new resin based hydrophobic powder has only limited impact on the listed measurements.



5 Illustration of salt transport through EN 196-1 mortar with no additive (C) or with 0.25 % SHP 50 (A) or with 0.25 % SHP 60+ (B) vs. drymix weight (cement + sand) Insert: schematic representation of the experimental set up



2.2 Impact of silicone hydrophobic powders on capillary water absorption

A set of mortar blocks were prepared according to EN 196-1 with a sand/cement ratio of 3/1 and a water/cement ratio = 0.5. Mortars with either no additive (as reference), with a silane/PDMS based powder (SHP 50) and with a new silicone resin-based powder (SHP 60+) at 0.25 % vs. the overall drymix weight were prepared.

Capillary water absorption of mortar blocks was measured according to EN ISO 15148. Mortar blocks cured for 28 days are placed horizontally in contact with water. The weight of the mortar blocks is measured as a function of contact time with water.

Figure 4 illustrates the improved hydrophobic performance of silicone resin-based hydrophobic powder.

One of the interests of integral water repellent is to ensure the longer lasting visual appearance of cement-based surfaces. Efflorescence is one potential deleterious process which can detrimentally alter the visual appearance of cement-based render due to the formation of white haze at the surface.

2.3 Efflorescence and its control

Efflorescence is due to the movement of water containing soluble salts through the interconnected pore system from the bulk of the mortar to the external surface. Upon water evaporation, the soluble salts will crystallize and leave a white haze on the surface.

Primary efflorescence is due to migration of calcium hydroxide produced during the initial phase of cement hydration to the surface. Upon reaction with atmospheric carbon dioxide, it produces water insoluble calcium carbonate, which is not easily washed or brushed off. This mostly happens in the cold and humid months of the year.

Secondary efflorescence is due to the transport of salts in already set/cured cement matrix.

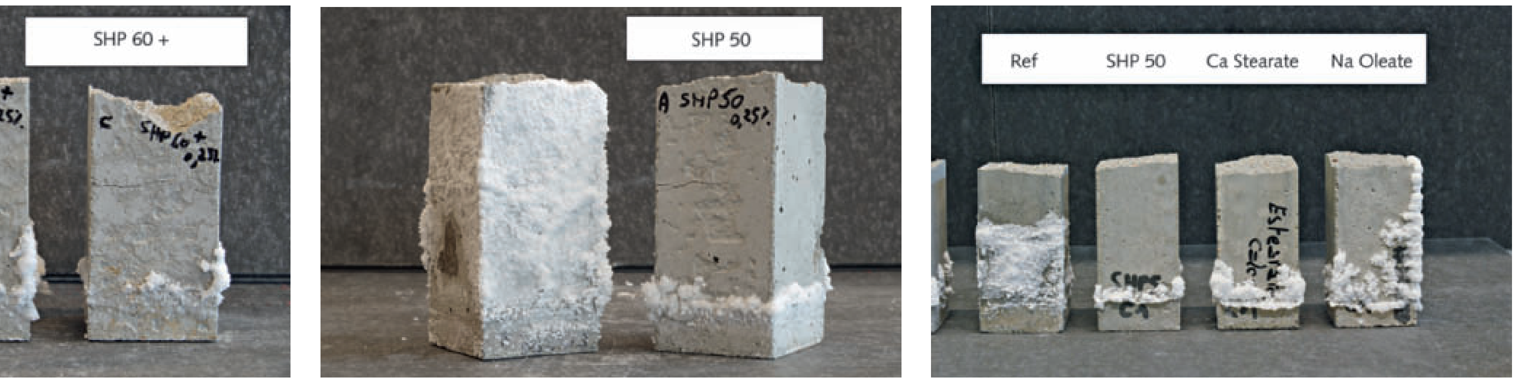
Mortar blocks were prepared according to the EN 196-1 norm (450 g of CEM II 32.5 N cement was mixed with 1350 g of normalized DIN sand with 225 g of water and different level of the silicone hydrophobic powder) and cured for 28 days before testing.

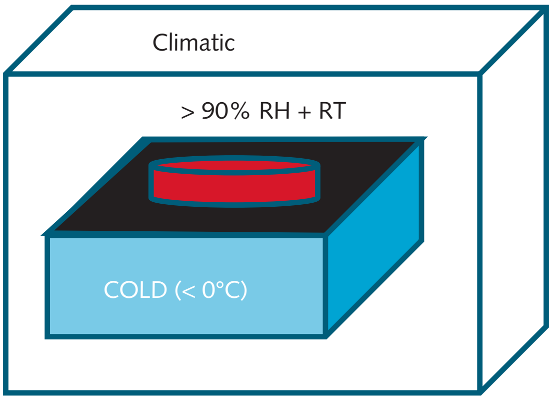
Reference and modified mortar blocks were placed vertically in a sodium chloride saturated solution in such a way that 1 cm of the blocks was immersed.

After a couple of days, salts transport through the reference mortar blocks is evidenced by the precipitation of salts at the surface. Blocks modified with silicone hydrophobic powders do not show evidence of efflorescence.

Although very simple, this test protocol enables the identification of difference of behaviour amongst different technologies of “hydrophobic powders”. Specimens of mortars of 4*4*16 cm^3 were used to

6 Illustration of salt transport through EN 196-1 mortar with no additive or with 0.25 % SHP 50 or with 0.25 % SHP 60+ vs. drymix weight (cement + sand) or with 0.25 % of different hydrophobic powders





7 Set-up used to evidence primary efflorescence

8 Surface of pigmented mortar (reference (A) or modified with 0.25 % SHP 60+ vs. drymix weight (cement + sand (B)) after setting in cold environment

assess mechanical properties. Two half specimens are produced after measurement of flexion. These half specimens were then used to measure compression strength. This means that these blocks are presenting some cracks and potential preferential pathways for water migration through the blocks. These blocks were used to design a more stringent test to assess secondary efflorescence and the impact of adding hydrophobic powder on efflorescence control.

The following pictures show the blocks which were submitted to the secondary efflorescence test protocol (Fig. 6).

Different behaviour can be observed. For example, hydrophobic powders which act as pore blockers in the cement matrix like calcium stearate or oleate do lead to uneven distribution of the particles and uneven control of water diffusion through the matrix. This is also observed when hydrophobic powder prepared by simple adsorption of silane on silica is used. In this case, uneven distribution of the particles is likely to come from their migration or uneven distribution during the mixing step.

Primary efflorescence was evidenced by carrying out an initial cure of pigmented mortar in a cold atmosphere.

The experimental set-up used to evidence primary efflorescence is illustrated hereafter. The disk of freshly mixed mortar (pigmented in red) is placed on a cold plate, which itself is placed in a climatic chamber, at room temperature but with relative humidity above 90 %. Being placed on a cold plate, the disk of mortar is fully covered with condensed water. After a couple of days, primary efflorescence can be evidenced.

The following picture shows the surface of reference and modified mortar after setting. The reference mortar shows efflorescence at the surface (white spots), while the surface of the modified mortar (with silicone resin based hydrophobic powder) is "defect-free" (Fig. 8).

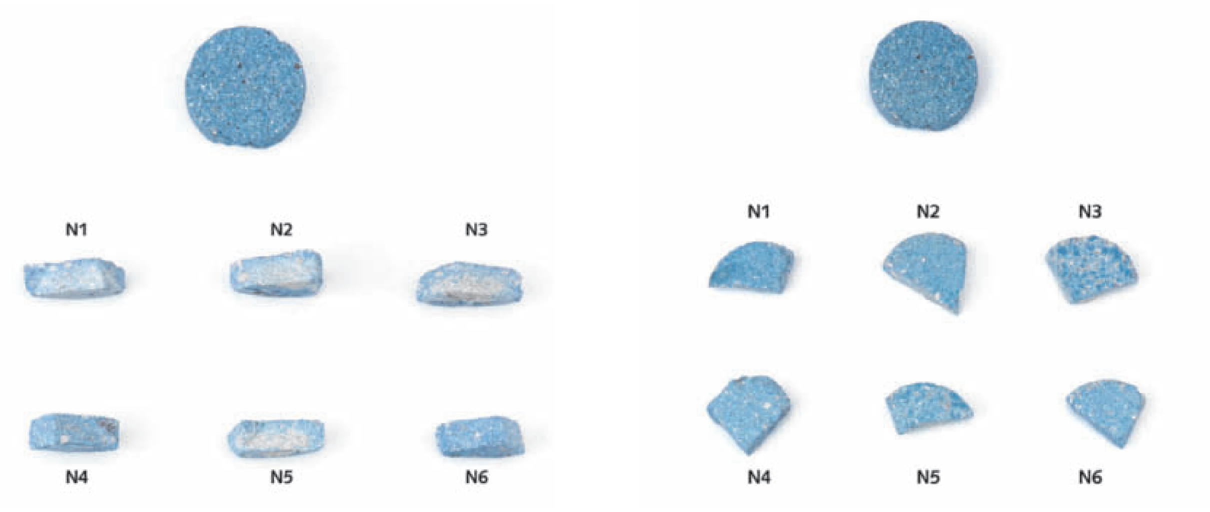
This set of results illustrates that addition of Silicone resin-based hydrophobic powder leads to significant reduction of primary and secondary efflorescence. Efflorescence (both primary and secondary) can then be strongly minimized by reducing the capillary water absorption and transfer of water through the cement matrix.

2.4 Color retention – use of ultramarine blue

Colored decorative renders are obtained thanks to the addition of pigments in the drymix formulation. Upon water-absorption and drying cycles, some pigments can be washed out from the cement matrix, leading to fading of the color. This is very aesthetically detrimental, whether for concrete pavers or facade renders.

Ultramarine blue pigment was used to characterize the benefit of integral water repellent on colour retention. Chemical reaction between conventional ultramarine pigments and cement during setting leads to color fading. Nubicem B-101 (made by Nubiola) is a chemically modified type of ultra-

Sample	Composition	Sample	Composition
Aggregates (Quarts and calcarous filler), 80 parts			
CEM III cement (20 parts)		CEM I cement (20 parts)	
Nubicem B-101 (4 % vs cement content)			
I1	No additives	N1	No additives
I2	+ cellulose	N2	+ cellulose
I3	+ stearate	N3	+ stearate
I4	+ Dow Corning SHP 50	N4	+ Dow Corning SHP 50
I5	+ stearate + cellulose	N5	+ stearate + cellulose
I6	+ Dow Corning SHP 50 + celulose	N6	+ Dow Corning SHP 50 + celulose



9 **Appearance of blocks after natural ageing (top and cross section view) of mortar blocks modified with different additives after two years natural ageing in Barcelona. Trends are identical when CEM III cement is used (series IX). White spots are due to the aggregates**

marine, compatible with cement based materials. In order to improve color retention, it is key to avoid prolonged contact with water (i.e. with high water cement ratio, long curing times with high humidity or regular contact with water when set). A study of the long term stability of the Nubicem B series in combination with different hydrophobic agents was carried out.

Different blocks were prepared by using CEM I or CEM III cement, by adding a water retention additive (methyl ethyl hydroxyethyl cellulose, (Bermocoll ML11@ 0.15 %)) and 0.5 % integral water repellent (stearate or silicone hydrophobic powder, as Dow Corning SHP 50) (Table 1).

The different mortar formulations were naturally exposed in Barcelona (Spain) for two years. Pictures of the blocks after ageing are shown hereafter (Fig. 9).

The pictures clearly illustrate that some depletion of the ultramarine pigment does occur in the cross section of most mortar blocks. This color fading of the interior of the specimen may finally lead to depletion of pigment at the surface and to surface color fading. Blocks modified either with cellulose ether, stearate or a mix of both hardly show any improvement of the cross section color fading. On the contrary, the blocks modified with SHP 50 hydrophobic powder show no cross section color fading, demonstrating the benefit of silicone hydrophobic powder on color retention of colored render or concrete blocks, and this through all sections of the blocks.

This set of results demonstrates the benefit of using the new Nubicem B series in combination with silicone-based integral water repellents like SHP 50.

3 Conclusions

This set of results clearly demonstrates the benefit of silicone hydrophobic powder for the protection of cement-based construction materials against the deleterious impact of water ingress. Protection against efflorescence and color fading is demonstrated.

Emerging new silicone-resin-based hydrophobic powder shows improved hydrophobic performance leading to better protection of the construction material against water ingress.

* First publication in: Drymix Mortar Yearbook 2015, idmmc five, p. 54-61

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In the Canary Islands, due to their volcanic origin, there is a lack of suitable clay to manufacture typical Spanish construction materials. Therefore, similar building construction materials are made using lightweight concrete with volcanic rocks (lapilli) instead of clay. Since the Spanish Technical Building Code (CTE) regulation entered into force the interior partitions and walls built using lapilli concrete blocks do not meet the minimum requirements. Therefore, the aim of this research is to improve the thermal and acoustic behavior of this concrete (from the Canary Island) by adding previously treated expanded polystyrene beads (EPS_t).

TEXT Pedro F. Yanes González[1], Mercedes del Río Merino[2]

Sample of manufactured conrete block

EUAT-ULL/EUATM

Lapilli cement mortar lightened with treated expanded polystyrene beads

1 Introduction

The Canary Islands present a special lithology – different from the rest of the Spanish mainland – as it is mainly characterized by volcanic materials and structures, forming a landscape dominated mostly by lavas of different nature and pyroclastic deposits, with a wide range of different compositions [1]. One of these pyroclastic deposits is the “lapilli”. This rock is caused by volcanic eruptions and consists of fragments ranging in size from 2 to 64 mm generally with irregular shape, vitreous and porous. It has a basaltic composition and it is characterized by its black color which changes to reddish due to an oxidation phenomena [2].

Moreover, the Canary Islands, due to their volcanic origin, have a lack of adequate clay for manufacturing conventional Spanish concrete materials (bricks, hollow bricks, etc.). This issue has significantly influenced the construction activity of the Canary Islands, as local resources (i.e. volcanic materials) have been constantly used as raw materials for manufacturing local construction products likewise the ones used on the Spanish mainland. This local building cement is lightened with volcanic rocks, mainly lapilli, instead of adding expanded clay as used on the Spanish mainland.

Since the Technical Building Code regulation entered into force in 2007 [3], studies of airborne

1 Dpto. Ingeniería de la Construcción, Escuela Universitaria de Arquitectura Técnica (EUAT-ULL/University School of Technical Architecture), La Laguna, Tenerife/Spain

2 Dpto. Construcciones Arquitectónicas, Escuela Universitaria de Arquitectura Técnica (EUATM/University School of Technical Architecture), Madrid/Spain

noise and heat resistance are performed on interior partitions and vertical building envelopes built with vibrated lapilli lightened concrete blocks currently placed on the market [4]. The result of these studies showed that partitions and vertical building envelopes built with these elements, without any other material, do not meet the minimum requirements set in the basic document "DB-HR Protection against noise" and "energy demand limitation" of the Technical Building Code regulation. Therefore it is necessary to include a second wall – block or drywall – placed in the interior in order to fulfill with the current regulation [5, 6].

Numerous research publications have been found analyzing lightweight concretes and mortars using different lightweight aggregates, such as expanded clay [7, 8]; expanded polystyrene [9]; rigid polyurethane foam [10] or even wood waste [11] and recycled plastics [12]. In general, these composites have lower densities and better thermal and acoustic behavior than traditional concretes or mortars. However, these reductions in density directly involve lower mechanical resistances [13].

In addition, from the previous literature, many works analyzing the characterization of mortars and concretes lightened with lapilli were found [14, 15, 16]. However, none of them analyzed the inclusion of other lightweight aggregates in addition to the lapilli.

Therefore, this research aims to determine the feasibility of a new building material based on lapilli concrete and cement mortar with treated expanded polystyrene beads (EPS_t) in order to enhance their thermal and acoustic performance. This new material will be used to manufacture concrete blocks.

2 Experimental plan and method

The experimental plan unfolds in three phases:

» 1st Phase – Materials characterization
» 2nd Phase – Reference mortar samples preparation (series I)
» 3rd Phase – Preparation of two series – seven samples each – using different proportions according to the percentage of treated expanded polystyrene (EPS_t) added (series II and III)

Table 1 Water analysis (performed at the Laboratory of Construction Quality of the Canary Islands' Government)

pH	8.84
Soluble content	0.539 g/l
Sulphate content (expressed as SO_3)	0.0 g/l
Chloride content	49.7 ppm
Qualitative sucrose (carbohydrates)	Does not contain
Qualitative glucose and other reducing sugars	Does not contain
Qualitative oil and fat	Does not contain

Table 2 CEMII/AP 42.5R analysis (Cement CEMII/AP 42.5R was used supplied by the Teide factory)

Composition	[%]	Composition	[%]
CaO	51.26	MgO	1.44
SO_3	2.94	Na_2O	1.35
SiO_2	27.64	K_2O	1.28
Al_2O_3	7.61	TiO_2	0.39
Fe_2O_3	3.06	P.F	3.00

Finally, standardized tests were conducted on all the above samples in order to measure:

1) Weight variation
2) Sound insulation
3) Thermal resistance
4) Mechanical resistance (bending and compression).
5) Water vapor transmission

2.1 Materials characterization

In a first phase, materials used in this study are characterized:

» Drinking water
» Cement
» Coarse and fine aggregate: lapilli
» Treated expanded polystyrene (EPS_t)

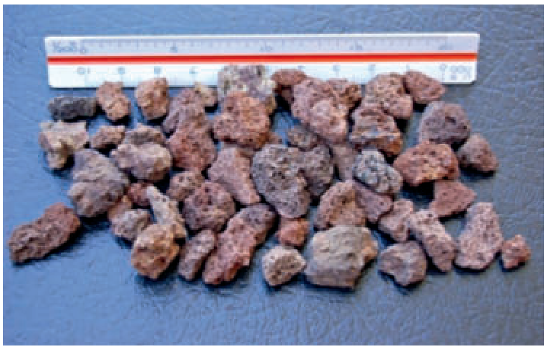
The results obtained are shown in Tables 1, 2 and 3. Table 3 shows a geotechnical characterization of weakly cemented pyroclast from the Canary Islands (Canary Islands Government Technical Report).

Virgin EPS beads sizing between 2 to 8 mm, gray colored and treated with a specific additive, allowing a better mixture of the polystyrene with water/binder, removing the floating phenomenon and ensuring a uniform distribution of the materials. The beads were manufactured by Politer [17].

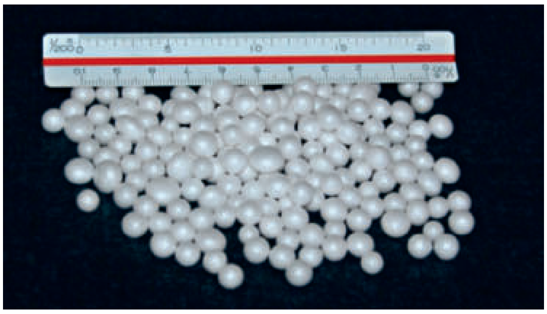
Table 3 Geotechnical characterization of coarse and fine aggregates

SiO_2	39.88 %	MgO	7.60 %	CO_2	0.00 %	Sr	1200 (ppm)
TiO_2	3.78 %	CaO	10.66 %	SO_3	0.05 %	Ba	700 (ppm)
Al_2O_3	12.52 %	Na_2O	3.48 %	S	0.07 %	Ni	100 (ppm)
FeO	0.00 %	K_2O	2.07 %	F	0.04 %	Cr	300 (ppm)
MnO	0.18 %	P_2O_5	0.96 %	CL	0.11 %	Zr	200 (ppm)

Volcanic rocks – lapilli



Expanded polystyrene beads (EPS_t)



2.2. Samples preparation

Samples were made at the Prefabricated Socas Company [18], following the same procedure as used to manufacture traditional vibrated concrete blocks. The samples preparation consisted of three phases:

Phase 1: Series I (PI) samples (Table 4) were performed using the same mortar as used in the factory for the production of traditional vibrated concrete blocks, so that their results serve as a reference for mortar samples made with lapilli and EPS_t. One third of the total mortar was used in each sample, vibrating it for 30 seconds and when reaching the end the mortar was also compacted (phase 2). For this, a metal cover was placed on the upper surface of the compound and fixed with two screws to the mold, allowing at last (phase 3) vibrating while compressing the mixture.

Phase 2: Test specimens of series II (P II) (Table 5) were prepared with the same mortar as PI, but once the mortar left the mixer, EPS_t (36.85 % of the total volume of the mixture) water (0.30 l) was added to a total of 126 l of mortar. The final mixture was used to fill the seven samples (62.91 % of lapilli mortar, 36.85 % EPS_t and 0.24 % of water). When adding EPS_t, the manufacturer's instructions for 200 kg/m³ of concrete density were followed (17), subtracting from the total EPS_t the amount of lapilli used in the mortar proportions.

Phase 3: Test specimens of series III (PIII) (Table 6) were prepared with the same mortar as PI, but once the mortar left the mixer, EPS_t (73.70 % of the total volume of the mixture) water (0.50 l) was added to a total of 126 l of mortar. The final mixture was used to fill the seven samples (lapilli mortar 25.93 %, EPS_t 73.70 % and water 0.37 %). The quantity of EPS_t added in these specimens, exactly doubles the amount added in Series II specimens.

2.3 Tests

After 28 days, the dried samples were taken to the Quality Construction Laboratory of the Canary Islands, where the following tests were performed:

Table 4 Series I mortar samples proportions

Series I (PI) samples proportions				
Materials	Type	Quantity	Consistency	Mixing
Cement	CEMII/AP 42.5R	230 kg	Dry	45-50 s
Water	Drinking water	130 l		
Fine aggregate	Fine lapilli (Ø 0/2)	200 kg		
Coarse aggregate	Lapilli (Ø 4/16)	1000 kg		

Table 5 Series II mortar samples proportions

Series II P(II) samples proportions				
Materials	Type	Quantity	Consistency	Mixing
Cement	CEMII/AP 42.5R	230.00 kg	Dry	45-50 s
Water	Drinking water	132.80 l		
Fine aggregate	Fine lapilli (Ø 0/2)	200.00 kg		
Coarse aggregate	Lapilli (Ø 4/16)	1000.00 kg		
EPS_t	36.85 % of the matrix volume			

Table 6 Series III mortar samples proportions

SERIES III P(III) samples proportions				
Materials	Type	Quantity	Consistency	Mixing
Cement	CEMII/AP 42.5R	230.00 kg	Dry	45-50 s
Water	Drinking water	133.97 l		
Fine aggregate	Fine lapilli (Ø 0/2)	200.00 kg		
Coarse aggregate	Lapilli (Ø 4/16)	1000.00 kg		
EPS_t	73.70 % of the matrix volume			

	Surface	Volume
Emitter room 1	13.34 m²	44.02 m³
Receiver room 2	10.62 m²	35.06 m³
Interior partition wall dividing both rooms	10.62 m²	
6 Lapilli concrete blocks	2.16 m² (placed in central part of the wall)	

Table 7 Characteristics of the rooms where the sound insulation test was performed

1) Thermal resistance
2) Mechanical resistances (bending and compression)
3) Water vapor transmission

2.3.1 Weight variation

In order to calculate the average weight of each series, the highest and lowest values were rejected and the mean weight of the remaining values was achieved.

2.3.2 Sound insulation

This test was performed as specified in the European Standards EN 140-4:1999 "Field measurements of airborne sound insulation between rooms". The tested building enclosure is located between two adjacent rooms in the basement of the University of La Laguna, on the central campus. These rooms meet the requirements specified in the standard (Table 7). The equipment used was "OmniPower" B&K 4296 Serial No. 2485239, consisting of an output power amplifier of around 300 W.

Calculation:

The measurements were performed on 1/3-octave bands. The parameter used to measure the airborne sound insulation is the standardized level difference D_{nT}, (Equation 1):

$$D_{nT} = L_1 - L_2 + 10 \log (T/T_0) \quad (1)$$

(L_1 = Sound pressure level in emitting room (room 1); L_2 = Sound pressure level in receiving room (room 2); T = Reverberation time in receiving room; T_0= Reference reverberation time (0.5 s))

Calculations for $D_{nT,w}$ (weighted standardized level difference) and for the different frequency ranges were performed according to UNE EN 140-4: 1999 and UNE.EN ISO 717-1: 1997 standards, respectively.

Procedure:

The measurements of airborne sound insulation are performed by placing the sound source (emitting pink noise) in two different positions inside the emitting room and performing a total average of ten random positions both on the emitter and receiver rooms. The reverberation time was obtained using two positions of the sound source and six microphone positions. Previously, the background noise and reverberation had been measured.

Five tests were performed in the interior partition wall separating two offices. This partition wall was modified throughout the tests, as follows:

1. Interior partition built with traditional vibrated concrete blocks (15 cm thick) and coated on both sides with plaster (17.40 cm of total thickness)
   Moreover, an opening of 180 x 120 cm was executed in the partition and was further filled in four different ways:
2. Using panels made with Series I, received with plaster

Preparation of the sample blocks

Samples	Mean weight [kg]	Percentage [%]	
P(I)	28.839	x	x
P(II)	21.979	23.79 %	x
P(III)	16.772	41.84 %	23.99 %

Table 8 Samples comparison of weight variation results

3. Using panels made with Series II, received with plaster
4. Using panels made with Series III, received with plaster, and plaster coatings on both sides (total thickness 7 cm)

2.3.3 Thermal resistance

The test was performed according to the UNE-EN 12664: 2002 and UNE-EN 1745: 2002 Standards. The objective of the test was to determine the heat flow of the samples under equilibrium conditions. The density of the heat flow ratio is measured using sensors located on the samples. A flow meter heat HFM 436/3/0 was used. The sample is placed between two plates kept at different temperatures (0 to 20 °C) during the test. Finally, the thermal conductivity is determined when the thermal equilibrium between the two faces of the sample is reached and there is a uniform temperature gradient in the whole sample.

Four specimens of 30 cm x 30 cm x 5 cm were tested for each series and polished on both sides until they were perfectly parallel. In order to obtain a constant mass of the samples, they were dried with an oven at 50 °C until the weight difference between two successive days was 0.1 %. The time taken to achieve this weight stability was fourteen days.

From the samples the following parameters are obtained:

Density: The density ρ_0 and ρc of the dried sample tested was calculated using equation 2:

$$\rho_0 = m_2/V \qquad (2)$$

(ρ_0 is the density of dry material; m_2 is the mass of the material after drying; V is the volume occupied by the material after drying)

Thermal resistance, R, was calculated using equation 3:

$$R = \frac{T1 - T2}{f\ eh} \qquad (3)$$

(f is the calibration factor of the heat flow meter; eh is the heat flow meter output; T1 is the sample temperature measurement on the hot side; T2 is the sample temperature measurement on the cold side)

And thermal conductivity, λ was calculated, using equation 4:

$$\lambda = \frac{f\ eh.d}{T1 - T2} \qquad (4)$$

2.3.4 Flexural and compressive strength

Three specimens of 160 mm x 40 mm x 40 mm were cut from the sample panels (60 cm x 60 cm x 5 cm). The flexural strength was determined following the UNE-EN 1015-11: 2001 standard, i.e. applying a load at three points (using rollers) until failure. The contact points of the rollers and the sides of the specimens were cleaned with a cloth in order to remove particles or other materials. The smoothest side of the specimen –the one in contact with the

Drying of the samples

Sound insulation tests of the samples

mold – was placed on the rollers. The load was applied at a uniform rate between 10 N/s and 50 N/s, so that failure occurred between 30 s and 90 s.

The two halves of sample specimens obtained from the flexural strength test were used to test the compressive strength, following the UNE-EN 1015-11: 2001 standard.

The load was applied gradually on a rate of between 50 N/s and 500 N/s such that the failure occurred between 30 s and 90 s. The maximum load applied during the test was recorded – in N. The resistance of each specimen was recorded to the nearest 0.05 N/mm^2. The mean resistance was then calculated with an accuracy of 0.1 N/mm^2.

2.3.5 Determining the properties of water vapor transmission

For this test, conducted according to the UNE-EN ISO 12572: 2001, method "C" was used as it is the least favorable and the most suitable to meet the requirements set by the CTE regulation, 11 cm x 11 cm x 5 cm specimens were performed. This sizing was chosen because the lab test plates had this section. Moreover, the thickness (5 cm) complies with paragraph (6.2.3) of the Standard, which specifies that the section of concrete with aggregates should be at least three times the largest particle size.

The samples were sealed to the open end of the test plate containing a water saturated solution and then they were placed in a test environment with controlled temperature and humidity.

Due to the difference in water vapor pressures between the test set and the chamber, a water vapor flow passes through the test specimens. The test set was weighed periodically to determine the resistance factor to water vapor when the steady state was reached.

The test was performed once the weight of the samples was stabilized. The lapilli mortar specimens with EPS_t adhered to the bassel and were laterally waterproofed with an adhesive sealant "Sikaflex 11 FC".

The set of specimens was introduced into the test chamber DYCOMETAL Model: CCM-0/19380. Specimens were weighted every 48 hours until five successive weightings variation in mass per unit time was constant within 5 % of the mean value.

The test results were calculated as follows:

For each set of successive weightings of the test specimens, the mass change (Δm_{12}) was calculated using equation 5:

$$\Delta m_{12} = \frac{m2 - m1}{t2 - t1} \qquad (5)$$

(Δm_{12} mass change per time for one determination [kg/s]; m1 mass of the test set at time t1 [kg]; m^2 mass of the test set at time t2 [kg]; t1 and t2 are successive weighting times [s])

The regression line between mass and time was calculated – excluding the previous test period (non-linear). The slope of this line is G, kg/s.

Table 9 Acoustic test results

Acoustic insulation tests		Dnt,w (dBA)
1st	The original wall that separated the two offices, built with vibrated concrete blocks 15 cm thick and coated with plaster on both sides.	39
2nd	Original wall modified with Series 1 (PI) blocks (0.60 x 0.60 x 0.05 m), made with the same proportions as mortar blocks from 1st test.	27
3rd	Original wall modified with Series 2 (PII) blocks (0.60 x 0.60 x 0.05 m), made with the same proportions as mortar blocks from 1st test, 36.85 % of the volume with treated expanded polystyrene and 300 cm^3 of water.	29
4th	Original wall modified with Series 3 (PIII) blocks (0.60 x 0.60 x 0.05 m), made with the same proportions as mortar blocks from 1st test, 73.70 % of the volume with treated expanded polystyrene and 500 cm^3 of water.	26
5th	Original wall modified as Series 3 (PIII) but coated with plaster on both sides (series PIII-A)	37

Table 10 Samples comparison of density, thermal resistance and conductivity results

Samples	Density	Thermal resistance R	Thermal conductivity $\lambda_{10.dry}$
P(I)	1451 (kg/m^3)	0.1346 (m^2K/W)	0.3450 (W/mK)
P(II)	-12.61 %	+19.69 %	-15.13 %
P(III)	-41.63 %	+103.64 %	-50.70 %

Table 11 Samples comparison of flexural and compressive strength results

Samples	Flexural strength	Compressive strength
P(I)	3.30 (N/mm^2)	10.60 (N/mm^2)
P(II)	-24.24 %	-35.85 %
P(III)	-78.79 %	-85.85 %

Furthermore, the density of water vapor flow, i.e. g, is calculated using equation 6:

$$g = \frac{G}{A} \tag{6}$$

(A is the is the exposed area of both sides)

Finally, water vapor retention, resistance to water vapor, the water vapor permeability and the resistance factor to water vapor were all calculated following UNE-EN ISO 12572: 2001 Standard.

3 Results and discussion

3.1 Samples weight variation

When EPS_t is added to traditional lapilli mortar, the weight of the samples decreases depending on the percentage added to the original proportions up to 41.84 % (Table 8).

3.2 Sound insulation

The acoustic insulation of the interior partition placed between the rooms improved when using samples containing EPS_t. The interior partitions built with Series II samples (PII) showed an improvement of 2 dBA over Series I (PI), as shown in Table 6.

Furthermore, when the interior partition was modified, the best results were obtained with specimens of the Series 2 (PII), despite having less percentage of EPS_t than Series 3 (PIII) samples. This could be justified because the last series contained more interconnected pores. Furthermore, it was found that in some areas the expanded polystyrene beads were not surrounded by mortar, were bonded in small groups, letting the noise pass without difficulty through the plate section.

Finally, P (III) samples with plaster coating on both sides obtained the best result, nearly reaching the value of the 1st test (Table 9).

3.3 Thermal resistance analysis

As shown in Table 10, adding EPS_t improves thermal resistance, making this material more thermal resistant than the original one. In addition, this phenomenon rises as the percentage of EPS_t increases.

3.4 Determining flexural and compressive strength

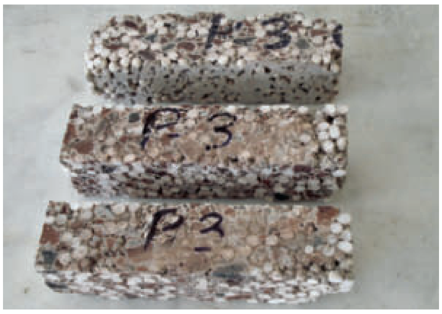
The resistance of the samples containing EPS_t, decreases in relation to EPS_t content (Table 11). The greater mechanical resistance reduction is reached in compression rather than flexural strength, achieving reductions of up to 85 %.

3.5 Determining the properties of water vapor transmission

Results from Table 12, show that P (II) proportions have better resistance than the reference sample P (I). Therefore, the water vapor resistance of the material improves when EPS_t is included in a determined quantity. This suggests that porosity and water absorption of the material decreases when adding EPS_t.

Moreover, P (III) samples exceed the optimal EPS_t proportions for ensuring a water vapor resistance, because the water vapor resistance decreases and consequently the water vapor permeability increases. However, this depends on the place where the material will be located and the requirements needed.





Sample series PI, PII and PIII

5 Conclusions

From the results obtained from the tests the following conclusions can be drawn:

When high percentage of lapilli is replaced by EPS_t significant improvements on sound insulation and thermal conductivity are obtained. However, adding high quantities of EPS_t is not the solution to increase the thermal resistance of the material, as high quantities of EPS_t weaken other properties. Therefore, the original materials composition needs to be optimized.

It is feasible to replace lapilli by treated expanded polystyrene (EPS_t) – up to 73.70 % of the total volume – in traditional lapilli mortars, maintaining an optimal workability of the blocks. Furthermore, a homogeneous mixture is achieved eliminating the floating phenomenon of the polystyrene beads. Adding EPS_t reduces the weight of the test samples up to 41.84 %. Nevertheless, strength properties are also reduced.

Testing of the samples

Therefore, this new material can be used for manufacturing vibrated concrete blocks meeting the requirements of the Spanish CTE regulation without having to place an inner second block wall or drywall and replacing the blocks currently used in the Canary Islands. This procedure has led to a patent which is in the process of commercialization (ref: P201132108).

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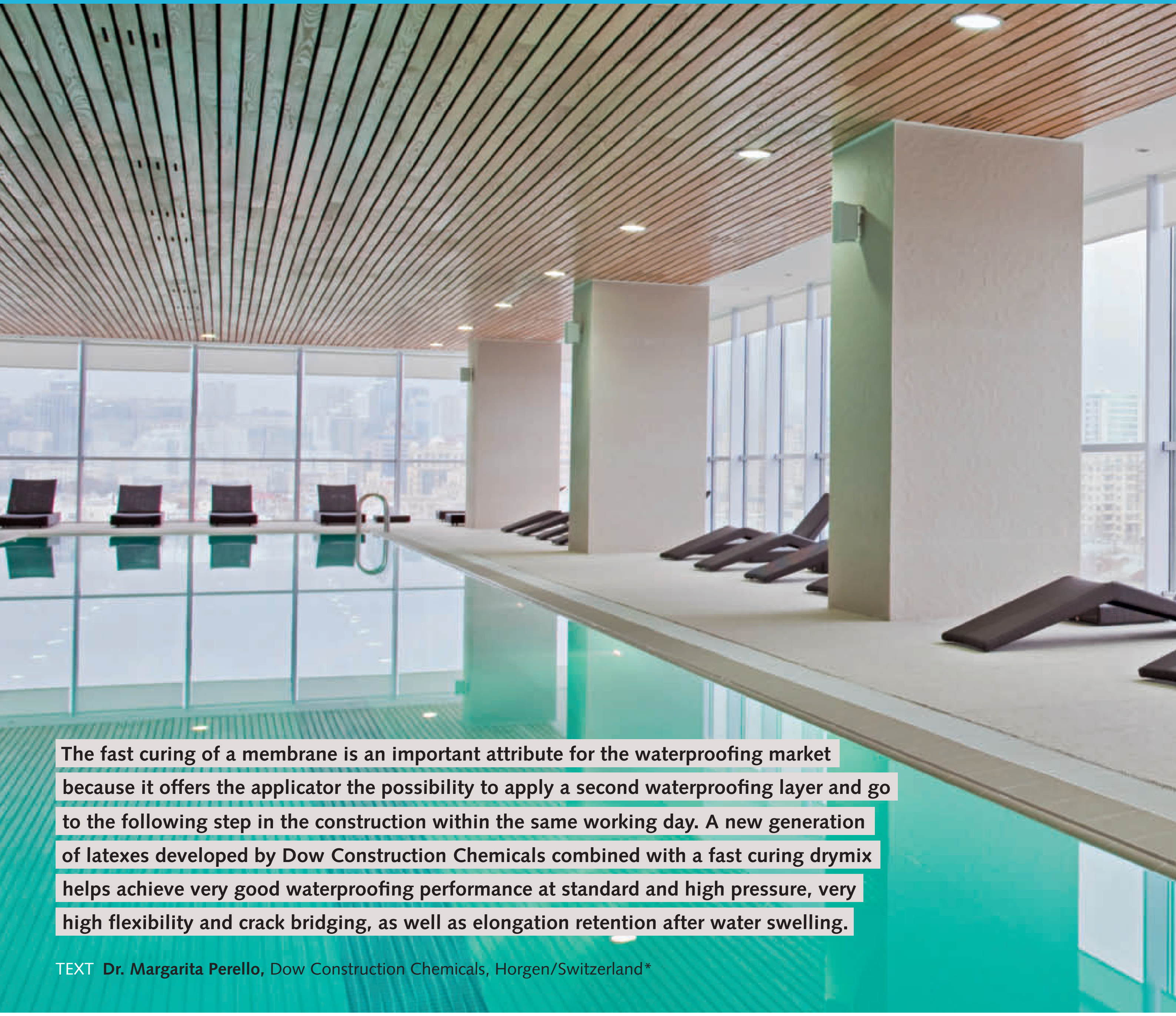


The fast curing of a membrane is an important attribute for the waterproofing market because it offers the applicator the possibility to apply a second waterproofing layer and go to the following step in the construction within the same working day. A new generation of latexes developed by Dow Construction Chemicals combined with a fast curing drymix helps achieve very good waterproofing performance at standard and high pressure, very high flexibility and crack bridging, as well as elongation retention after water swelling.

TEXT **Dr. Margarita Perello,** Dow Construction Chemicals, Horgen/Switzerland*

DOW CONSTRUCTION CHEMICALS

New binder technology for 2K fast curing waterproofing membranes

A drymix formulated with fast cement and combined with standard latex results in a very short pot life mortar and a membrane that lacks flexibility and very often has cracks and hence is not waterproof. The new latexes provide long enough pot life to allow good workability and still enabling the application of a new layer on top of the first layer within 0.5–2 h. This new technology will provide the waterproofing market an environmentally advanced option for both interior and exterior applications.

* This publication is based on the presentation given at the idmmc five, Nuremberg/Germany (20.04.2015)

One field of application for 2K fast curing waterproofing membranes

Leading picture: Shutterstock/Evru

1 Introduction

Faster curing waterproofing membranes can be achieved by using fast setting cement like calcium alumina cement (CAC). However, there are multiple challenges when using emulsion polymers in fast setting cement compositions. As the wet mortar thickens very fast, the applicability and workability becomes very difficult; pot life is unacceptably short and the resulting membrane is too rigid, and thereby lacks flexibility and often cracks so that it is not waterproof. Further, in fast setting compositions, the emulsion polymer does not provide enough flexibility to give sufficient crack bridging in dry/wet conditions. One way to solve the problem of the rigidity of the resulting membrane would be to reduce the glass transition temperature (Tg) of the emulsion polymer, making it softer and more flexible, and/or to increase significantly the polymer to cement ratio. In both cases the solution impacts the membrane cost.

An effective fast curing sealing membrane would enable the applicator to apply a first and a second layer within the same working day. If the application is in a basement – as a replacement of bitumen – the next step in construction could follow after 24 h instead of several days later.

Table 1 Formulation of dry component in the 2K system

Drymix	%
OPC CEM I 42,5R	25.30
CAC	12.00
$CaSO_4$	2.70
Quartz sand FH32	36.40
Quartz sand FH36	23.45
HEMC	0.15

Table 2 Main parameters of Dow and competitor's latex used in commercial products

Latex Reference	Polymer Chemistry	Tg [°C]	Solid [%]	Process
Sample A	Styrene- Butylacrylate	-8	56	Y
Sample A ,	Styrene- Butylacrylate	-8	56	X
Sample B	Styrene- Butylacrylate	-30	56	Y
Commercial Products				
System F	Styrene- EHA	-14	50	
System R	Styrene- EHA	-14	50	

The present study has sought to solve the problem of providing a two-component composition of a fast curing drymix and an emulsion polymer additive that makes a wet mortar composition suitable for use as a fast curing waterproofing membrane without significantly reducing the Tg of the polymer or increasing the polymer to cement ratio in the composition, while enabling both acceptable mortar pot life and flexibility in the final cured membrane so that it does not crack while curing.

2 Materials and test methods

2.1 Materials

The latex samples of the present study have been tested in the drymix formulation described in Table 1. The main properties of the latex binders tested are summarized in Table 2.

2.2 Test methods

2.2.1 Preparation of the membrane mixture

The liquid components are weighed into a beaker and mixed for 30 seconds at 200 rpm. The well mixed dry components are added carefully under stirring within 45 seconds. When all solid components are added, the slurry is stirred at 700 rpm for 2 min15 sec.

2.2.2 Pot life/viscosity increase

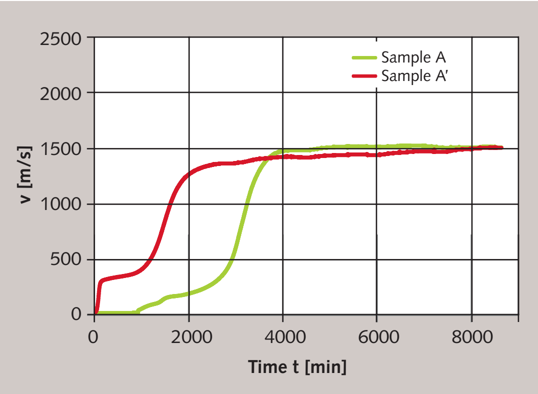
The freshly prepared membrane mixture is immediately transferred into a steel beaker. The steel beaker was jolted five times by hand and then the surface was smoothed with a scraper. By weighing the steel beaker the density is determined. 30 seconds after the beaker is filled the viscosity is measured the first time. This measurement will be done also after 5, 15, 30, 45, 60, 90 and 120 minutes. The viscosity is measured with a Brookfield RVT DV-II viscometer at 5 rpm with a T spindle on a Helipath stand at 23 °C/50 % RH.

2.2.3 Cement setting with ultrasonic tester

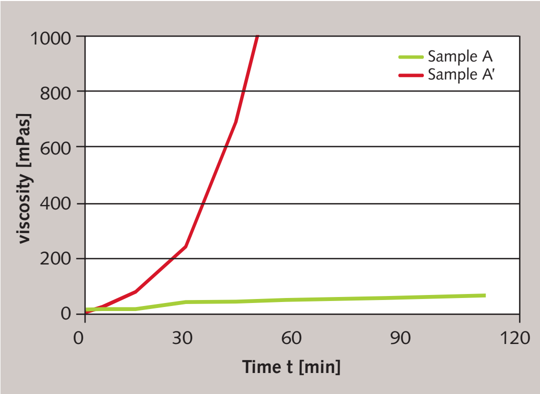
The freshly prepared membrane mixture is put into the testing chamber. An ultrasonic pulse will be sent from the transmitter to the receiver and the speed will be recorded. As the membrane becomes harder, the sound travels faster. The setting will be measured over seven days.

2.2.4 Water impermeability according to EN 12390-8

Prepare a limestone brick with a drilled hole on the obverse side of the testing surface. The freshly made membrane mixture is applied at 1.3 mm thickness in one layer on the limestone brick. After 4 h a second 1.3 mm layer of a freshly made membrane mixture is applied on the first layer. Let it dry for seven days at 23 °C and 50 % RH. Put a water indication paper into the drilled hole. The membrane with the limestone is put into the water impermeability tester and a hydrostatic pressure of 1.5 bars is applied on the membrane for four days. If the water absorption is less than 25 ml raise up the pressure to 5 bars. If the absorption is higher than 25 ml, hold the pressure an additional three days at 1.5 bar. After seven days the water indication paper will be checked. The test is passed if no humidity is seen underneath the membrane. In parallel the water loss over time is read from the calibrated cylinder of the water impermeability tester.



1 Cement setting profile using ultrasound equipment. The mortars measured are prepared with sample A and A' using the same fast drymix (Table 1)



2 Pot life of mortar prepared with samples A and A' in the same fast drymix (Table 1)

Figures 1-8: Dow Construction Chemicals

2.2.5 Elongation and tensile strength measured according to DIN ISO EN 527-1 and DIN ISO EN 527-2

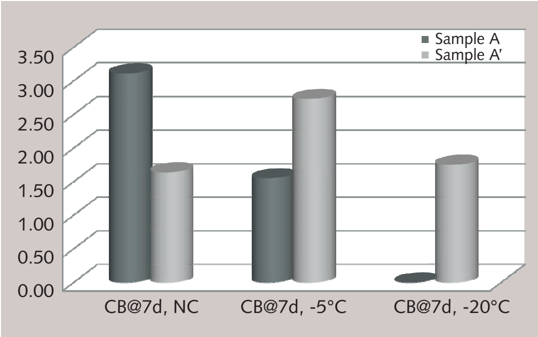
Two different curing conditions are applied. The first one is curing of the membrane at 23 °C/50 % RH for seven days and the second one curing for seven days at 23 °C/50 % RH and additional seven days under water (23 °C). Curing time was shorter than usual (28 d or 7 d + 21 d under water) because the comparison data were needed as soon as possible. In a known formulation the data after seven day curing are good enough for comparison purposes. Optionally the elongation and tensile strength can be measured at -5 °C and -20 °C. The freshly prepared membrane mixture is applied at 2.6 mm thickness in one layer onto a Teflon film. The membrane is cured for seven days at 23 °C/50 % RH. After curing 14 specimens are cut out from each membrane. Half of the specimens are immersed into water for seven additional days (23 °C), the other half are measured immediately. The specimens for the water immersion test would be tested wet. Elongation and tensile tests are run in a texture analyzer at a speed of 20 mm/min.

2.2.6 Crack bridging according to EN 14891

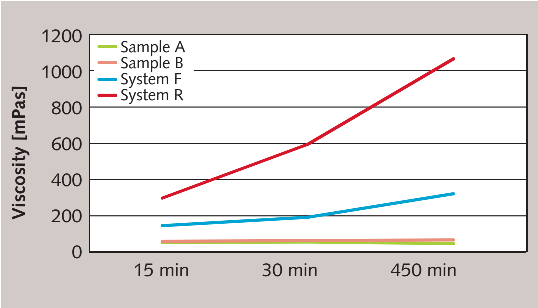
For this test concrete specimens (160 x 50 x 12 mm) are homemade according to EN 14891 from fresh mortar. The freshly prepared membrane mixture is applied with a metal frame of 3 mm thickness on one of the 160 x 50 mm sides of the concrete specimen and let it dry for 4 h. Then new freshly prepared membrane mixture is applied on the other side of the specimen using the same frame. The membrane is cured for 7 or 28 days. After curing time the concrete specimen is broken carefully. The broken concrete specimen with the intact membrane is elongated with the texture analyzer at 0.15 mm/min. The surface of the membrane is monitored visually. The distance is reported when (A) at maximum force (B) the first cracks appear. Additionally the maximum force is reported. For measures at low temperature, specimens would be stored over night at the -5° C or -20 °C.

2.2.7 Static crack bridging according to EN 1062-7

For this test hydrophobic concrete specimens (160 x 50 x 12 mm) are used. On the reverse side there is after 80 mm a 3 mm deep gap as a rated break point. The freshly prepared membrane mixture is applied with a metal frame of 3 mm thickness on the top side of the concrete specimen. The membrane is allowed to cure for 28 days. After curing time the concrete specimen will be fixed in a special bent equipment to break the specimen over a wanted angle to get a gap of 0.4, 0.75 or 1.5 mm at the rated break point.



3 **Crack bridging results according to EN-14891 of membranes prepared with sample A (Tg -8 °C) and sample B (Tg -30 °C) and measured at different temperatures. All membranes were cured during seven days**



4 **Viscosity build up of wet mortar membrane prepared with a fast drymix system**

The crack of the membrane at the rated break point is monitored visually by grading:

» Grad 1: no crack
» Grad 2: white break
» Grad 3: thin crack not passing over total wide
» Grad 4: thin crack > 1 mm
» Grad 5: crack < 1 mm
» Grad 6: immediately crack after breaking

This test can be done also at low temperature. In this case there will be a cool down to the needed temperature for least 3 h before breaking over the wanted angle.

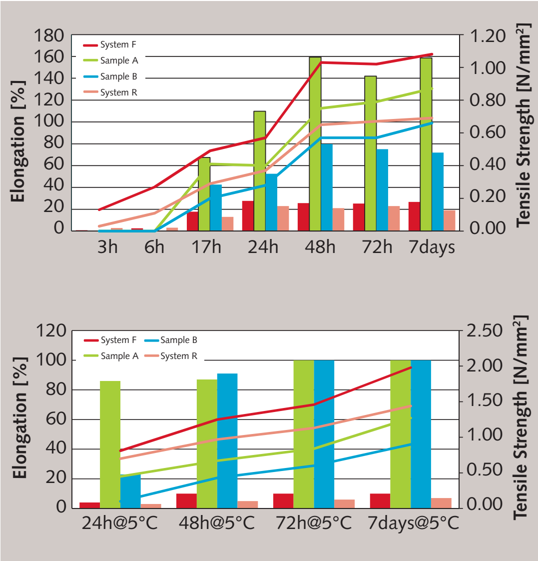
2.2.8 Adhesion strength according to EN 1542

The freshly prepared membrane mixture is applied at a thickness of 2.6 mm onto a hydrophobic concrete slab. Adhesion is measured after:

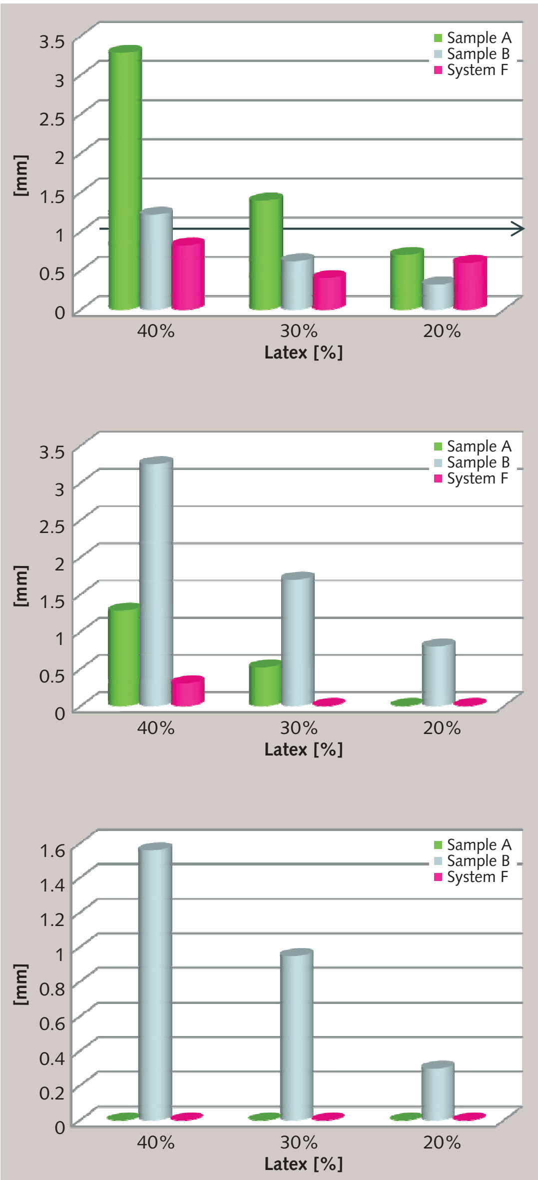
» (A) 7 days and 28 days storage at 23 °C/50 % RH
» (B) 7 days storage at 23 °C/50 % rel. humidity and 21 days in water
» (C) 14 days at 23 °C/50 % RH and 14 days at 70 °C (air circulation) additional 1 day at 23 °C/50 % RH

3 Results and discussion

The evolution of a cement paste from a soft material to a hard solid occurs in several stages. By designing the right latex, the aim is to control the correlation between cement hydration and cohesion evolution of the final composite – flexible membrane – in that case. When cement is mixed with waterborne latex,



5 Early strength development in terms of elongation and tensile at room temperature and at -5 °C



6 Crack bridging according to EN-14891 at room temperature, -5 °C and -20 °C at different binder dosage

each cement phase dissolves at least partially, leading to the establishment of a supersaturated solution with respect to the different hydrates, which can precipitate [1]. But in order to obtain a rapid hardening and a rapid drying a hydraulic binder mix containing Calcium Aluminate Cement (CAC) in combination with Portland Cement (OPC) and/or Calcium Sulphate (CS) is required. It has been found that the early hydration reactions are always dominated by the ettringite formation – aluminum, sulphate and calcium ions in solution [2]. The formation of ettringite results from nucleation and growth from solution. The chemical reactants – aluminum, calcium and sulphate ions in – come from the dissolved solid mineral constituents for which the equilibrium solubility constant is $K_{ett} = 4.9 \times 10^{-44}$. The rate of nucleation and growth of crystals depends, amongst others things, on the supersaturation coefficient β which is related to the energy available for the formation of the nuclei that in the case of ettringite is [3]:

$$6Ca^{2+} + 2Al(OH)^-_4 + 3SO_4^{2-} + 4OH^- + 26H_2O \rightarrow 3CaOAl_2O_3 \cdot 3CaSO_4 \cdot 32H_2O \quad (1)$$

$$\beta = (a\,Ca^{2+})^6 \cdot (a\,Al(OH)_4^-)^2 \cdot (a\,SO_4^{2-})^3 \cdot (aOH^-)^4/K_{ett} \quad (2)$$

The "a" coefficients are the ion activity (which is the ion concentration multiplied by the activity coefficient γ). For crystallization to occur β must be greater than one. Kinetics of nucleation depends strongly on the concentration of calcium ions in solution and fairly strongly on the hydroxyl ion concentration or pH of the media [4]. With the right latex design it would probably be possible to control the different ion activity and hence growth conditions of ettringite formation which result in different crystal morphology and crystal quantity that will strongly influence the mortar properties. The two latex samples A and A' (which composition is summarized in Table 2) have an identical backbone but they have been produced following different processes: The hypothesis is that when mortar slurry is prepared using sample A, β < 1 while with sample A' β > 1. In Figure 1 and 2 could be observed the difference in wet mortar behaviour; speed of nucleation phase while measuring cement setting and pot life of membranes prepared respectively with sample A and A'.

Both cement setting and pot life for sample A' are extremely fast and result in a very rigid, non-cohesive membrane due eventually to a too fast/uncontrolled crystallization of ettringite during nucleation phase, while sample A for which pot life and also setting profile are much longer, provides a highly flexible membrane. As indicated in Table 1, Tg and polymer backbone for sample A and sample A' are identical. This is therefore clear evidence that a low polymer's Tg is not enough to guarantee good flexibility.

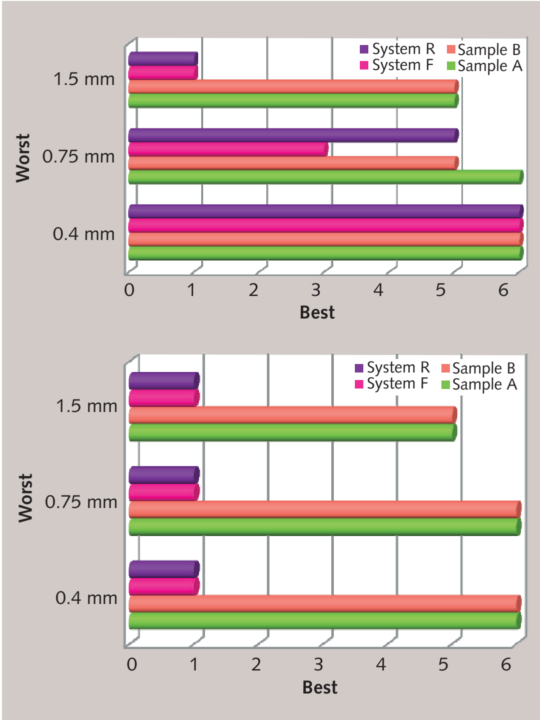
The previous statement applies at room temperature but as shown in Figure 3, to obtain deformation at low temperature (-20 °C), a very low Tg is necessary. Only sample B, with Tg -30 °C, provides deformation at -20 °C. Both sample A and B have been produced following the same production technology especially adapted to fast drymix systems.

As mentioned in the beginning of this report the aim of the project was to develop a binder that combined with a fast drymix would enable applicators to work long enough with wet slurry, resulting in sufficient pot life and at the same time to develop strength fast enough to be waterproof as soon as possible. Figure 4 shows pot life data of the two binders developed (samples A + B) with the new technology compared to commercially available fast systems (samples F + R). The tested systems are building up viscosity slower than the commercially available one. However, when we look at the early strength development both at water impermeability results as shown in Table 3, and also in terms of elongation/tensile at low temperature over time, as presented in Figure 5, we could confirm that the new technology provides superior performance in absolute terms of timing and mechanical strength compared to commercially available systems.

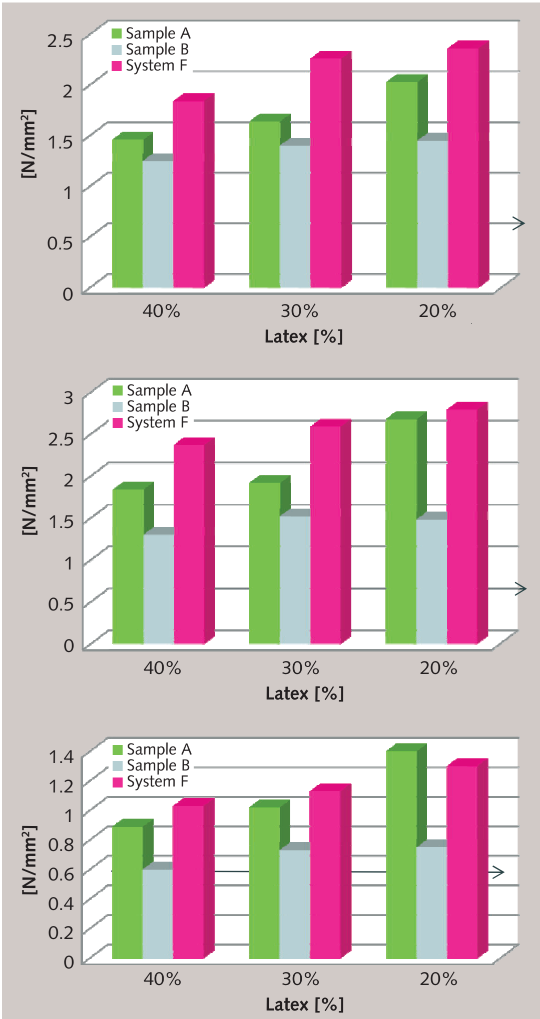
Results are self-explanatory and we could state that after 24 hours both at room temperature and at 5 °C the membranes prepared with the new binders have developed more than 80 % of the total mechanical strength and the absolute value is so high, that membranes are already water proof even under the highest pressure conditions.

Another important attribute that the 2K waterproofing market expects from a binder is efficiency. If one takes a very low Tg pure acrylic binder and loads a high dosage of polymer, it is possible to get the desired outcome but at a very high price. The outstanding mechanical strength values in terms of elongation and tensile at room temperature with sample A and at very low temperature with sample B enables each a very efficient system.

As shown in Figure 6 and Figure 7, the EN-14891 crack bridging and adhesion standard can be reached at lower latex dosage compared to commercially available systems. When the membrane is used in basements or as concrete protection, the required standard is EN-1504-2 in which flexibility is measured following static crack bridging. This test, in particular at low temperatures, is very dif-



7 Static crack bridging according to ETAG 1504-2 at 5 °C and -5 °C



8 Adhesion strength values of membrane using different latex dosages measured according to EN-1542

Table 3 Waterproofing results of membranes cured 24 h and 3 days at 5 °C

Waterproofing EN 12390-8	Sample A	Sample B	System F	System R
Curing 1 day at 5 °C/ml water after 7 days at 1.5 bar	5	0	90	420
block under WPM wet?	no	no	yes	yes
Curing 3 days at 5 °C/ml water after 3 days at 5 bar	0	0	1000	1000
block under WPM wet?	no	no	yes	yes

ficult to pass when the membrane is prepared using a fast drymix. Figure 7 presents the static crack bridging results of sample A and B in comparison to system R and F using commercially available binders. It could be shown that the technology helps to achieve significantly improved results.

The results showed a significant difference, in particular at low temperature. The new latex technology will enable formulators to produce fast curing membranes with a differentiated performance.

4 Conclusions

With a new latex technology the control of the β initial nucleation phase enables superior mechanical performance of the final membrane during cement hydration in a ternary binder system. The Tg and polymer backbone are not sufficient parameters to predict performance of a cementitious membrane. A very low Tg (< -20 °C) and a right polymer backbone are critical to develop crack bridging at -20 °C. The new technology supports formulation of differentiated 2K fast curing waterproofing membranes for which flexibility is a key parameter under extreme conditions, providing highest performance of static crack bridging in particular at -5 °C. The new latex technology imparts simultaneously long pot life and early strength development at low temperatures. It helps achieve waterproofing capability after 24 hours at 5 °C and has shown especially high latex efficiency.

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Bauverlag BV GmbH
Avenwedder Straße 55
PO Box 120, 33311 Gütersloh/Germany

Editor-in-Chief
Dipl.-Ing. Anett Fischer
Tel. +49 5241 80-89264
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Editors
Holger Reiff
Tel. +49 5241 80-89279
holger.reiff@bauverlag.de
Anke Bracht
Tel. +49 5241 80-89368
anke.bracht@bauverlag.de

Editorial Office
Sabine Anton
Tel. +49 5241 80-89365
sabine.anton@bauverlag.de

English Translators
Robin B. C. Baker, Cranbrook/Great Britain
M. Eley, Duisburg/Germany

Designer
Kerstin Berken
Tel. +49 5241 80-2128
kerstin.berken@bauverlag.de

Advertising Manager
Ingo Wanders
Tel. +49 5241 80-41973, Fax +49 5241 80-641973
ingo.wanders@bauverlag.de

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Managing Director
Karl-Heinz Müller
Tel. +49 5241 80-2476

Publishing Director
Markus Gorisch
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Marketing and Sales
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Terra Melhor
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Brazil 12 243261
Tel. +55 1298 2355000
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Hong Kong: Margaret Mo
m.mo@bciasia.com
BCI Asia Construction Information Ltd
Unit 1002, 10/F, Euro Trade Centre
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Central Hong Kong
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Indonesia: Bobby Rahadian
bobby@bciasia.co.id
PT BCI Asia
Manggala Wanabakti Building
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Jl. Jend. Gatot Subroto 102708
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Singapore: Mr. Louis Lee
l.lee@bciasia.com
BCI Asia Construction Information Pte Ltd
371 Beach Road, #02–25 Keypoint
Singapore 199597
Tel. +65 6538-6836
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Vietnam: Mr. Nguy Thanh Vi
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BCI Asia Vietnam Co., Ltd.
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The Philippines: Ms. Apple Patricio
apple@bciasia.com
BCI Asia Philippines Inc.
Units A & B 15/F Trafalgar Plaza
H.V.Dela Costa St. Salcedo Village
Makati City/Philippines 1200
Tel. +63 2 884-1122
Fax +63 2 884-1121

Malaysia: Mr. Kelvin Yong
k.yong@bciasia.com
BCI Asia Construction Information Sdn Bhd
Unit 615, Blk E, Phileo Damansara I,
Off Jln Damansara, No 9, Jln 16/11,
Petaling Jaya, Selangor/Malaysia 46350
Tel. +60 3 7661-1380
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Australia: Mr. Robert Krups
r.krups@bciaustralia.com
BCI Australia Pty Ltd
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