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DRYMIX MORTAR
CONSTRUCTION CHEMISTRY

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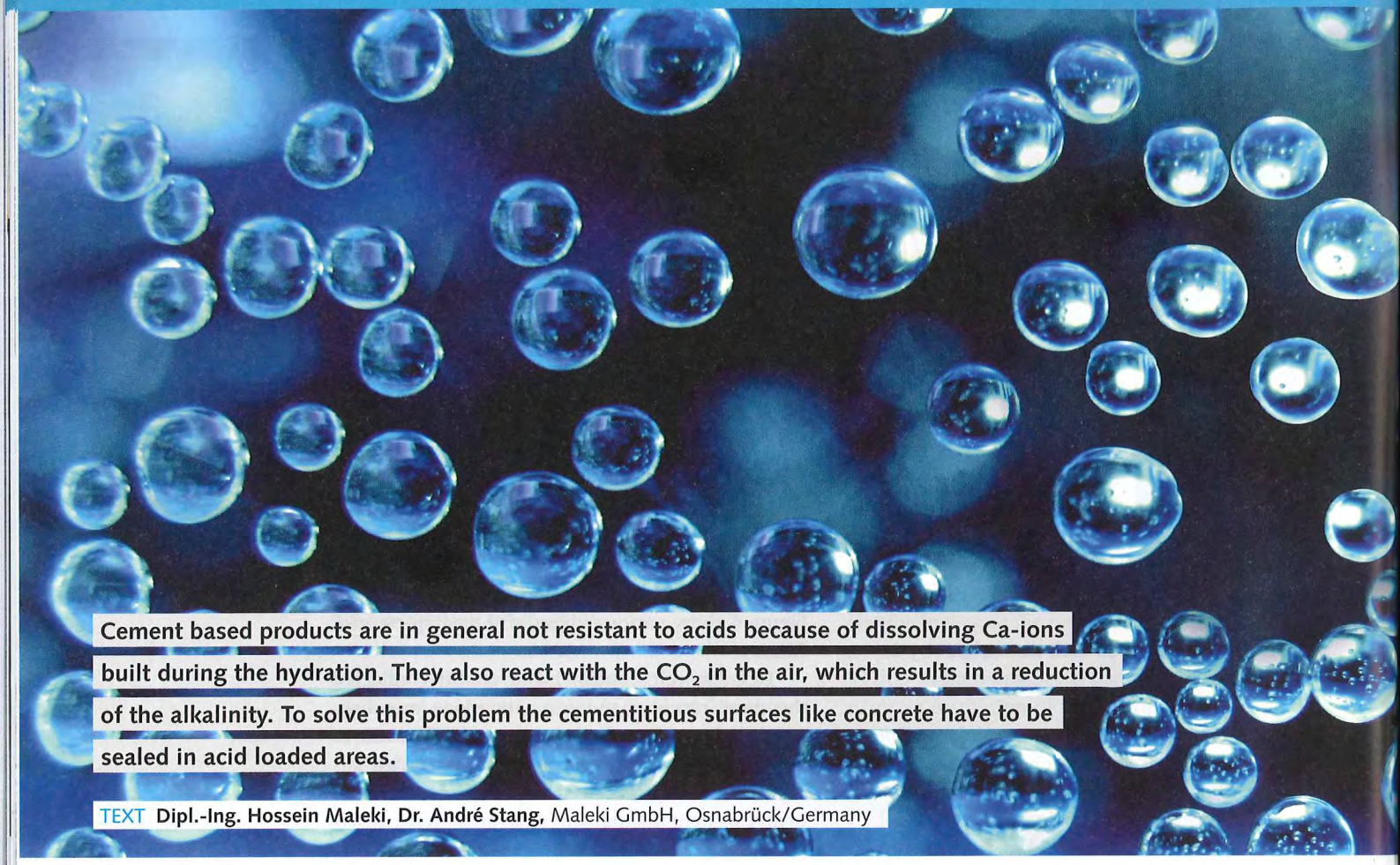

Cement based products are in general not resistant to acids because of dissolving Ca-ions built during the hydration. They also react with the CO_2 in the air, which results in a reduction of the alkalinity. To solve this problem the cementitious surfaces like concrete have to be sealed in acid loaded areas.

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MALEKI

Innovative silicate products for areas with high acid and corrosive load

1 Introduction

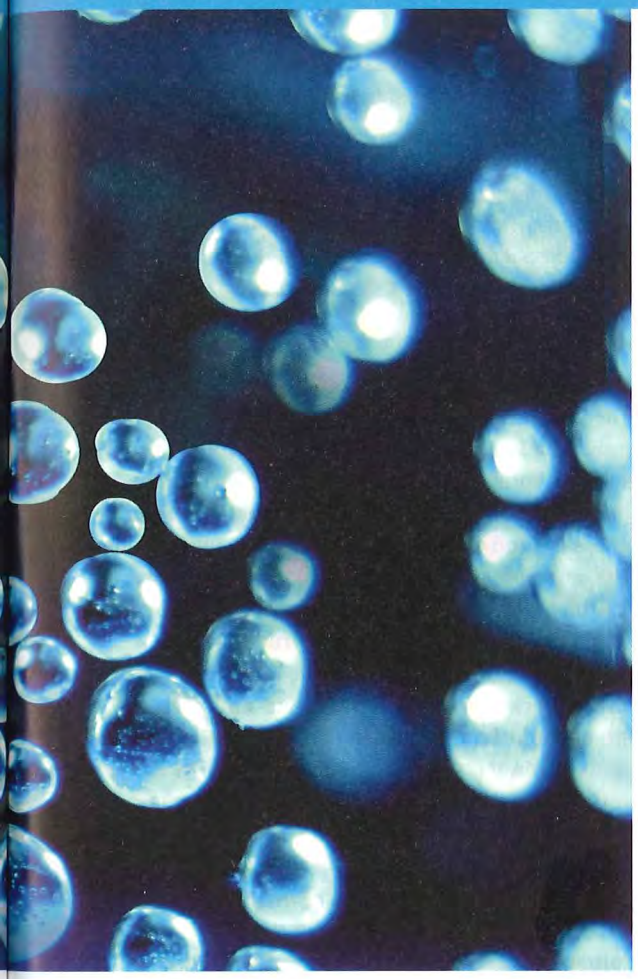
It is well-known in research and industries that cement-based products are in general not resistant to acids. Ca-ions built during the hydration dissolve already in small quantities in water and cause efflorescence as well as spalling inside the concrete matrix. They also react with the CO_2 in the air, which results in a reduction of the alkalinity. The formation of ettringite, salts and efflorescence are a direct result of the reaction with Ca-ions.

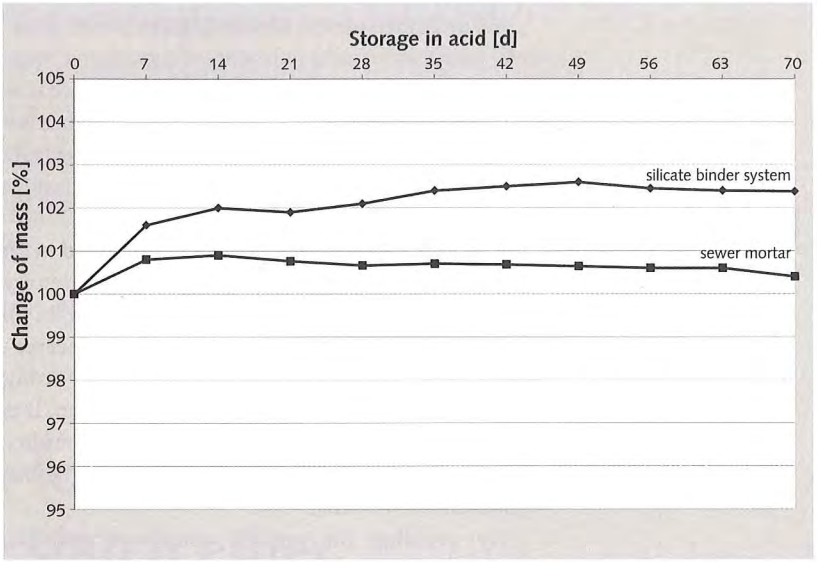
To solve the above-mentioned problem the cementitious surfaces like concrete have to be sealed in acid loaded areas. The author describes a potassium based liquid silicate material and a single-pack coating mortar based upon propriety hydraulic binders and silicates to solve the above-mentioned problems permanently. This silicate mortar can replace epoxy or polymer coatings and its properties excel over their performance.

2 Conventional systems

To increase the acid resistance of cementitious construction materials or to avoid corrosion, protective coatings are applied to the concrete and mortar surfaces in critical areas like acid load areas to prevent aggressive fluids coming into contact with the highly reactive calcium ions contained in the cement. Until today there was no effective treatment agent that was able to solve these problems permanently.

There are many treatment agents, sealer or coatings for the protection of concrete or cementitious products available on the market. These products can be summarized inter alia as silanes, siloxanes, waxes, epoxy resins, polymer coatings and other organic products. All these products have either an organic basis, are not UV-resistant, not scratch resistant, not permanently stable and lose their protection mechanism after some time. In addition to the material properties, key factors including the preparation





1 shows the comparison of the single-pack silicate binder (◊) and sewer mortar (■) stored in acid by analyzing the change of mass

of the substrate, the quality of the application, and whether the integrity of the coating play an important role throughout the service life to ensure the integrity of the coating system. Summarized, up to now there is no existing coating system which is a long-lasting solution to the problems.

To give an example, epoxy resins are often used as a protective coating for cementitious surfaces. But when working with epoxy resins the following points and disadvantages should be considered:

Epoxy resins are:

» not high temperature resistant
» only applicable on dry surfaces
» two component and harmful
» based on organic material, which is produced by using oil
» not applicable at higher or lower temperatures

Former silicate products tried to replace epoxy resins but succeeded only in certain areas. The following problems were identified:

» two components
» no early exposure to water
» difficult to apply

3 Next generation of silicate products

The latest knowledge in research of silicate binder system for dry mortar products to replace epoxi resins or other coatings solve the above-mentioned problems by using a single-pack and environmentally friendly silicate binder system.

The 100 % cement free inorganic single-pack binder system is formulated by using silicate raw materials and can be adapted for any dry mortar product like water proofing, tile adhesive, joint filler, etc.

In contrast to other protection systems like epoxy resins or polymer coatings the silicate binder system respectively the resulting products reacts with the calcium ions of the substrate due to the abundance of silicates. The resulting transformation of the highly reactive calcium ions leads to several positive effects like a strong adhesion to the substrate, even if they are non-absorbent and smooth, prevention of negative infiltration of aggressive chemicals and destruction of the surface and strengthening the surface.

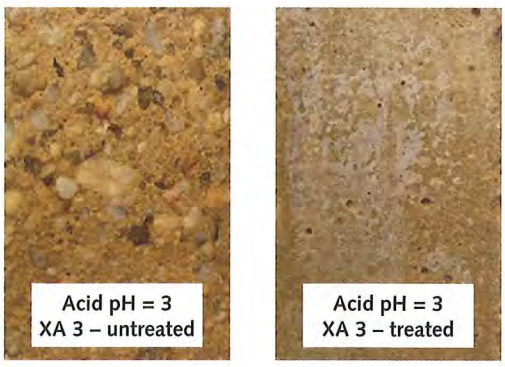
Storage	Acid		Water		Air	
	Flexural strength [Mpa]	Compressive strength [Mpa]	Flexural strength [Mpa]	Compressive strength [Mpa]	Flexural strength [Mpa]	Compressive strength [Mpa]
Silicate	4.91	51.5	5.92	52.5	6.04	48.5
Sewer mortar	5.48	44.1	6.34	54.3	6.33	51.9

Table 1 shows the increase of compressive strength of the silicate binder system due to water storage or acid storage in comparison to a sewer mortar, whose compressive strength is decreasing during storage in acid

As described above, former silicate-based products, which were used to replace epoxy resins, were shown to be problematic during processing because of correct mixing of the components, application on a wet surface, curing at high humidity, early exposure to water, etc. The single-pack silicate binder system solves these problems.

The single-pack binder system is mixed with water and cures under the support of water by forming a silicate matrix with high density (Tab. 1). This allows, for example, water pressure impermeability up to 1.5 bar (15 m water column) by using water proofing with a layer thickness of 3 mm. It is applicable on wet surfaces, cures at high humidity (Tab. 1) and mixing of several components before application is avoided.

By avoiding the organic binder components, which are used in resins or in former silicate products, the chemical resistance is also increased (Fig. 1). Figure 1 shows a comparison of a highly resistant sewer mortar and the silicate binder system. It is shown that the sewer mortar loses mass dealt to the acid attack (Fig. 1) and undergoes a reduction of the compressive strength (Tab. 1). In contrast the silicate binder remains constant during the storage period of 70 days and even increases the compressive strength (Fig. and Tab. 1). Therefore, the silicate binder is resistant against inorganic or organic acids, solvents and bases (for example 2 % sulfuric acid – pH = 0 and 1 M potassium hydroxide – pH = 14) and provides a pH resistance from 0 up to 14.



2 shows the comparison of a treated (by the liquid silicates) and untreated concrete specimen of the class XA3 stored in lactic / acetic acid for 28 days at a pH of 3

In contrast to the one component silicate mortar the liquid silicates avoid the damage by corrosive loads by optimizing the concrete matrix. It reacts directly with the Ca-ions by penetrating into the substrate and forms a silicate structure inside the concrete substrate. The resulting silicate matrix provides a significant higher resistance to acid load or salt attacks (Fig. 2). This resulting higher chemical resistance is accompanied by the effects of strengthening the surface, closing the pores, and avoiding of efflorescence.

Compared to the 1st generation products the liquid silicate is based on potassium silicate instead of sodium silicate. Therefore, it does not lead to efflorescence and has a better penetration depth owing to the smaller molecular size. Moreover, it introduces a hydrophobic effect at the same working flow whereby the hydrophobicity and the strengthening of the substrate are provided in one product.

As a result the easy application of the non hazardous liquid silicates and the resulting improvement of a non-resistant cementitious substrate to an acid resistant substrate extend the service life of the building structure or the cementitious substrate considerably.

4 Conclusion

The 2nd generation of the silicates from Maleki GmbH provide a long lasting and environmentally friendly solution to avoid the introductory named problems like their lack of acid resistance, formation of ettringite, salts and efflorescence of cementitious products. The common alternatives like epoxy resins, polymer coatings and 1st generation silicate products formerly used resolve these problems only rudimentarily.

With the 100 % inorganic and cement-free single-pack silicate binder system and the potassium based liquid silicate the Maleki GmbH presents a binder system or solutions which do not suffer from the same disadvantages of the common epoxy or polymer coatings and 1st generation silicate products.

Beside the advantages and benefits, the innovative 2nd generation silicate products are environmentally friendly because they avoid organic components, are produced by using secondary raw materials and are high performance solutions for highly corrosive areas with the following advantages and benefits:

- applicable on wet surface and at high humidity
- no hazard labeling required, non-hazardous
- no allergy potential and solvent free, VOC-free, odorless
- extreme density and adhesion to the substrate even if they are non-absorbent and smooth
- reacts with Ca-ions from the substrate - preventing negative infiltration of aggressive chemicals and destruction of the surface
- heat resistant up to 1350 °C
- no efflorescence and no harmful effects on concrete or masonry
- easy handling by mixing with water, pumpable
- eco-friendly alternative to epoxy resins or other coatings
- environmentally friendly - very low carbon footprint
- permanent solution of the protection problem of cementitious surfaces loaded with aggressive chemicals
- suitable for channel, biogas plants, sewage treatment plants, manure tanks and all salt water, chemical loaded areas, hospitals, etc.