INFORMATION SCRIPT

Concrete Curing Agents

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Deutsche Bauchemie e. V.
Mainzer Landstrasse 55
60329 Frankfurt am Main
Telephone: +49 69 2556-1318
Telefax: +49 69 2556-1319
www.deutsche-bauchemie.com

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www.netmark5.de

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1 CURING AGENTS FOR CONCRETE

The production of high quality concrete surfaces calls for a specifically focused concept when it comes to the curing of the concrete. In terms of industrial standards, DIN EN 13670, Execution of Concrete Structures, in Point 8.5, Paragraph 5, has this to say with regard to the protection of concrete in the first few hours: "After the compaction and surface treatment of the concrete, the surface is to be immediately provided with curing treatment. If it is intended that crack formation in the exposed surface resulting from premature shrinkage is to be avoided, an intermediate curing treatment is to be carried out before further surface treatment."

In general terms, the purpose of curing is to protect the fresh concrete, until it reaches an adequate degree of hardness and strength, against drying out, extreme temperatures, precipitation, the effects of foreign substances, and harmful vibrations and shocks, so as to avoid damage and achieve the qualities required of the concrete.

Achieving this aim may require the application of different measures for the curing process, which if necessary may have to be used in combination. It is in any event recommended that a curing combination be worked out which is specific to the application involved. Chemical curing agents (NBM) such as they are regarded in this information brochure are a fundamental part of this.

Concrete curing agents are substances which are applied in fluid form onto the surface of the green, or fresh, concrete. With uniform application, as a rule by spraying, a film is formed, which to a great extent prevents the reduction of water from the concrete due to evaporation. With regard to the form of delivery, a distinction is drawn between aqueous systems or those containing solvents. Products containing solvents, however, are of subsidiary significance on the German market.

Films and chemical curing agents are in general only applied when the concrete has become matt moist, or the last processing stage, the surface finish, has been completed. Between the application and the subsequent processing stage, such as smoothing or broom finish, it is often the case that no curing treatment is carried out, and during this period, the lying time, the fresh concrete is unprotected. Depending on the climatic conditions, a substantial amount of surface evaporation takes place during this phase, which can be considerably reduced by the use of a suitable intermediate curing agent.

2 FIELDS OF APPLICATION / OPERATIONAL AREAS

2.1 General concrete construction / civil engineering

In line with the requirements of the Standard DIN 1045-3, the purpose of curing is to ensure that excessive water evaporation by way of the surface of the concrete is prevented.

As suitable curing agents, paraffin wax dispersions are used if this is not to be followed by a coating or painting of the surface. Otherwise, curing agents based on polymer dispersions are used, which, if used correctly before the application of a paint layer, do not have to be removed.

As an alternative to the use of suitable curing agents, DIN 1045-3 makes reference to the following processes:

- Leaving in the shuttering
- Covering the concrete surface with vapour-proof films
- Laying of water-storing coverings, kept constantly moist while at the same time applying evaporation protection
- Maintaining of a visible film of water on the concrete surface (for example by spraying)

2.2 Vehicular traffic surfaces made of concrete / aviation surfaces

With regard to vehicular traffic surfaces made of concrete, according to the ZTV specification Beton-StB 07 curing treatment is a mandatory requirement. To carry out the curing process, wet treatment, covering with films, the application of coverings holding water, or the use of curing agents are specified. Due to the machine-based production of the carriageway surface with a slip-form paver, the application of curing agents is practically the exclusive technique. In this context chemical curing agents are used which are based on aqueous paraffin wax dispersions.

2.3 Industrial floor surfaces

For the production of industrial floor surfaces, the concrete is protected during the lying phase for the first 3-5 hours with an intermediate curing agent. After the further surface treatment, the long-term treatment is carried out either with films or with fluid curing agents. In this context, either paraffin wax dispersions or polymer dispersions are used.

3 REQUIREMENTS FOR CURING AGENTS

The different concrete curing agents are subject to different national and international standards and bodies of regulations.

The most important German regulatory provision is TL NBM-StB 09, "Technical conditions for the supply of fluid concrete curing agents", issued by the FGSV, "Research Association for Road and Traffic Matters".

This body of regulations draws a distinction between curing agents with certification by the manufacturers' in-house production quality control, and curing agents with a manufacturer's declaration.

- With curing agents with certification by the manufacturers' in-house production quality control, regular monitoring, assessment, and acknowledgment is carried out by an independent certification authority. This certification is officially recorded by the certification authority engaged.
- With curing agents with a manufacturer's declaration, proof must be provided of concordance on the part of the manufacturers with the conditions of delivery and supply.

An identification marking of curing agents with the CE mark is not possible, however, since there is no harmonized European product standard for concrete curing agents, and therefore no basis exists for a CE marking.

The scope and frequency of the in-house production quality control are specified in Table 4 of the Technical Guideline NBM-StB 09.

The various different applications are represented in the bodies of regulations:

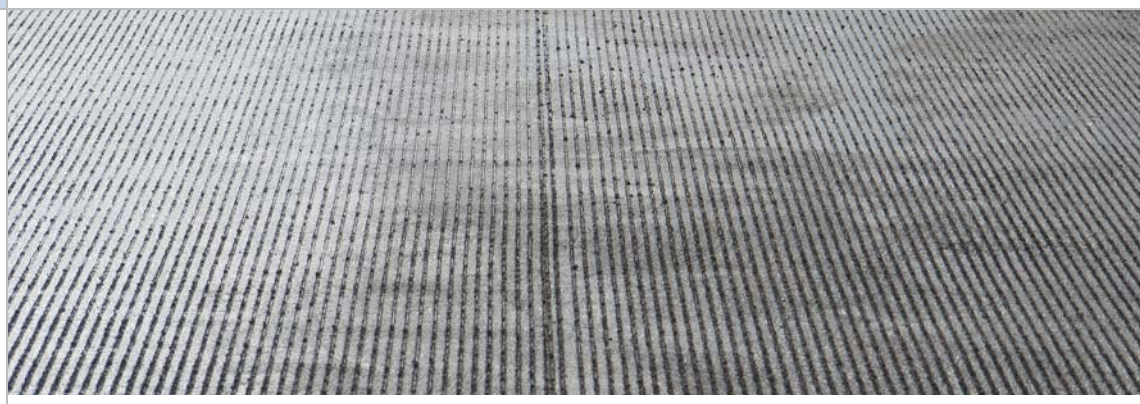
Depending on the scope of application, a distinction is drawn between:

- "Concrete for highway surfaces (road construction with a grip requirement for the surface)",
- "Concrete for highway surfaces (road construction without a grip requirement for the surface)" and
- "General concrete construction (concrete for construction sections without grip requirements)".

These applications are assigned the abbreviations: **V**; **A**; and **B**.

At the time of application, a distinction is drawn between immediate, matt moist, and after shuttering removal. In this case we have the abbreviations: **H**; **M**; and **E**.

Important instructions about working in respect of curing and the protection of the fresh concrete are also to be found in the concrete technology / cement fact sheet B8 [4]. The minimum duration for curing is described in DIN EN 13670/DIN 1045-3 [3].



In addition to the national bodies of regulations, there are also a considerable number of international standards.

Important standards are, for example:

- ASTM C 309-11 (USA)
- AFNOR NF P 18-370 (France)
- RVS 11.064 Testing Methods, Concrete (Austria)

The national and international bodies of regulations for curing agents describe and explain both the requirements for the agents as well as the testing methods and procedures.

TL NBM-StB 09 distinguishes between requirements for the curing agent and requirements for the curing agent film.

Requirements for the curing agents are the capacity for being sprayed, the flash point (only for systems containing solvents), and storage stability.

They must also not contain any hazardous substances which could disadvantageously alter the setting and hardening of the concrete close to the surface (this does not apply to type AH products). Nor may any substances be contained which could impair the corrosion protection of the reinforcement.

The most important requirements for the curing agent film are the barrier coefficient, the gripping capacity, the drying time, the luminosity coefficient, and the weathering behaviour.

The barrier coefficient describes the barrier effect of a curing agent with regard to the water loss of the fresh concrete, which must attain a specific value. For the determination of the barrier coefficient, a precisely defined fresh concrete (grading curve, cement, water / cement value, temperature, etc.) is prepared. The curing agent is sprayed onto the concrete at specific application times, depending on the type of use, and the water loss is determined in comparison with a control sample. Depending on the type of use or the abbreviation code, the attaining of different barrier coefficients is a mandatory requirement.

4 PROCESSING / TYPES OF APPLICATION

Processing

When using curing agents, the specific processing instructions from the technical data-sheets issued by the manufacturers must be respected. In order to achieve the desired protective effect, however, the following basic principles apply in general, which should be respected for all types of application:

Uniformity and continuity in application

The effect of the curing agent is dependent on the uniformity and continuity of the protective layer applied. The protective effect can only be fully established with a film which is applied evenly and with complete continuity. In order to achieve this, the curing agent is sprayed on as a fine mist, evenly and covering the whole of the concrete surface.

The freshly applied curing film often initially appears white on the surface. This allows for any deficiencies in application to be relatively easily identified. Different application thicknesses, however, can lead not only to a reduction in the protective effect, but may also produce patches on the surface. It is therefore essential that a uniform application is ensured.

Remove moisture on the substrate

The curing agent cannot form the barrier or protective film which is desired if there is moisture present. This means that puddles and pools of water must be removed before the application.

As well as this, the concrete which is to be protected should not be bleeding (any longer), and should not have any glistening water film evident.

Take the temperature into account

At very high or very low temperatures, addition curing agent measures may be necessary. In the first instance, curing agents protect the concrete against drying out.

They do not provide any protection against cold, high temperatures, or extreme changes of temperature.

Avoid contamination

Clean equipment should always be used. Contamination and mixtures with other products, including other curing agents, are to be avoided. These can have the effect of flocculation and render the curing agent unusable, or clog the nozzles of the spraying equipment.

Layering and spreading

Aqueous curing agents must be stored so as to be protected against frost. The effects of frost will render the material unusable. In general it is also recommended that all curing agents should be protected against strong sunlight.

If the curing agent has been kept in storage for any considerable length of time, it should be homogenized, for example by stirring or shaking.

Application of further materials

If further materials are being applied, such as coatings, bonding agents, or paints, it should be borne in mind that curing agents must normally be removed beforehand.

Types of application

Curing agents are, as a rule, sprayed onto the concrete surface. The spraying equipment suitable for this varies depending on the purpose of application, but in general a distinction can be made between three types of application:

Spray beam

For the construction of roads or other surfaces for use by vehicles, curing agents are typically applied by a spraying device on the stage towed by the slip-form paver, onto the matt moist concrete surface.

Illustration 1: Towed stage unit

One particular feature characterizes the production of washed concrete surfaces in roadway construction. In this situation, two different curing agents are required, which are applied at different times of the construction process.

Illustration 2: Spray beam

In order to be able to produce the washed concrete surface, the uppermost layer of concrete or mortar is brushed. In order to ensure that brushing is carried out simply and cleanly, the setting behaviour of the concrete surface is retarded with the aid of a curing agent of the combination product type (surface retardant), while the concrete underneath is allowed to harden unimpeded.
The surface retardant is, as a rule, applied directly following the production of the carriageway surface, by the spray beam on the stage towed by the production vehicle.

After the brushing of the surface mortar, the finished washed concrete surface is then protected against evaporation by spraying on the second curing agent (of VM type).

This second curing procedure is typically carried out with the aid of a spray beam, mounted on a construction vehicle.

Motorised spraying equipment on other horizontal concrete surfaces

With large horizontal surfaces, such as industrial building floors, the curing agent is often applied with motorised spraying equipment.

Illustration 3: Motorised spraying equipment

Pressure spraying equipment with vertical concrete surfaces

In building construction and with smaller horizontal surfaces, a pressure spraying device is frequently used.

Illustration 4: Pressure spraying device

Processing time

With exposed concrete surfaces, the agent should be applied as soon as the visible water film has disappeared and the concrete surface appears matt moist. With concrete in shuttering, application takes place immediately after the shuttering has been removed. In both cases, the concrete which is to be protected must not have any glistening water film, and must not still be bleeding, since otherwise no barrier or protective film with proper continuity will form.
The Technical Guideline NBM 09 distinguishes between three different times at which curing agents can be applied to the concrete. Curing agents are categorised into the following three types, corresponding to these times:

Curing agent type	Application / processing time
Type H	Immediately (normally only used in highway construction)
Type M	In the matt moist state
Type B	After removal of shuttering

The curing agent should therefore be selected so as to correspond to the application.

5 PRODUCT TYPES

Concrete curing agents are, as a rule, low-emission products.

Concrete curing agents are also predominantly classified in class WGK 1 (weakly water polluting).

The products are to be identified in accordance with their content substances in accordance with the CLP Regulation. Classifications regarding transport usually do not exist.

For storage and transport the applicable national and european regulations are to be respected.

The Professional Association of the Construction Industry (BG Bau) has built up a hazardous Ordinance information system (GISBAU) in support of its member companies, which provides contractors with comprehensive information regarding Hazardous substances, and largely relieves them of fulfilling their obligations with regard to investigation, monitoring, and providing instruction in accordance with the Hazardous Substances Ordinance. The core of the system is the provision of product informations and instructions based on model forms of procedure in accordance with the Directive.

In co-operation with the manufacturers of concrete curing agents, and in concordance with Deutsche Bauchemie e.V., a product group information service has been developed which is tailored to the requirements for concrete curing agents.

The product code **NBM 10** for "concrete curing agent, solvent-free" is used in the manufacturers' information and applied to the container labels, which enables the user to assign the product precisely in relation to the GISCODE. This accordingly provides information about the protective measures required for a large number of products. The instructions relate to the pure product. The concrete curing agent manufacturers provide GISBAU with the product information for this purpose.

5.1 Paraffin and other waxes

In highway construction in particular, wax-based curing agents are widely used. This mainly involved paraffin wax. This is a product from the petrochemical industry. It occurs at the deparafinning of mineral oil. Virtually no use is made of biological, synthetic, or Fischer-Tropsch waxes as curing agents.

As a rule, this involves wax emulsions, which are applied on the fresh or matt moist concrete. After the evaporation of the water, they should form a film which is as uniform and has the greatest continuity possible (see film formation of a wax emulsion). This wax film ensures that the water remains in the concrete and is available to the cement for hydration, in order to ensure high quality of the concrete and prevent damage (reduced strength, cracking).

After spraying, the emulsion forms a white layer. Due to the evaporation of the water, a colourless transparent wax film is formed. With high quality products, the dried wax film is rainproof and not re-emulsifiable. This is associated with the high melting point of the wax. It can only emulsify above that temperature. The emulsions should not be applied below a temperature of 5 °C (frost risk).

In highway construction, the wax film weathers away with time due to construction site traffic and UV radiation. With other construction components, in particular subsequently applied coatings, the wax film must be removed.

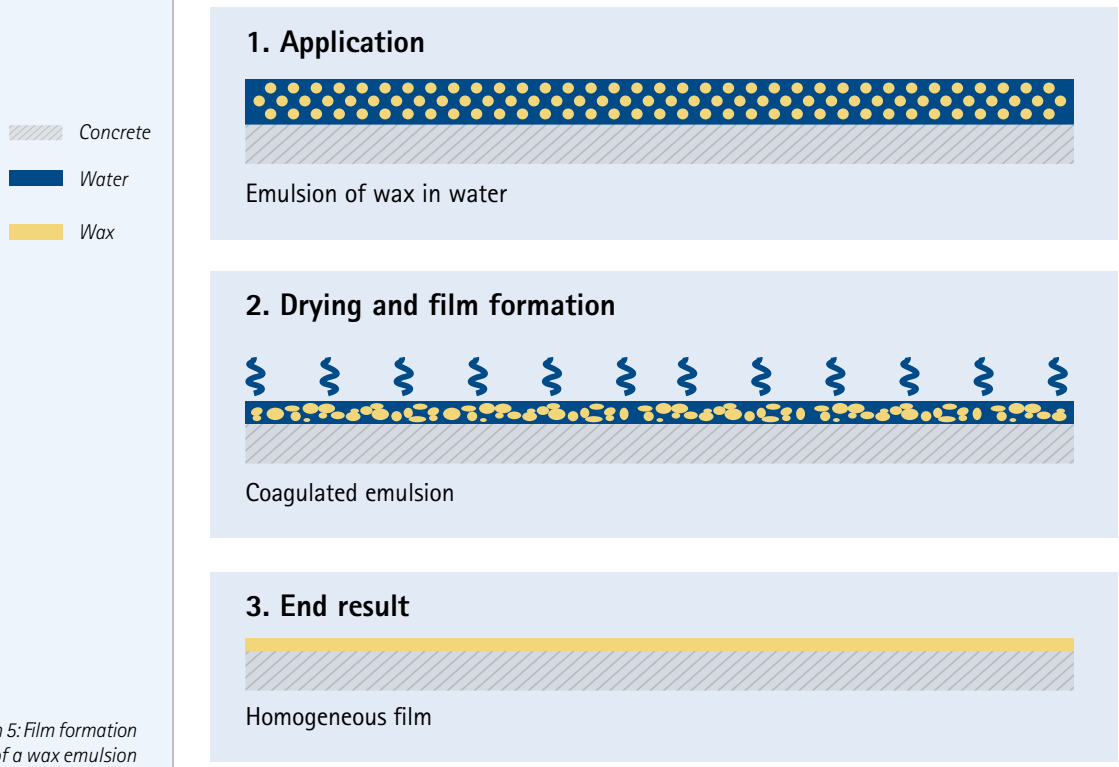


Illustration 5: Film formation of a wax emulsion

5.2 Aqueous polymer dispersions

A further group of concrete curing agents are the "aqueous polymer dispersions".

In this context, polymer dispersions on an acrylate base are predominantly used.

As with conventional paraffin dispersions, aqueous polymer dispersions are sprayed onto the fresh concrete. After drying, the polymer particles form a uniform film on the concrete surface, which prevents further evaporation of water, and therefore prevents the concrete from drying out. These concrete curing agents can also be processed by brush and roller application.

A major advantage with aqueous polymer dispersions is that the following processes (such as paint systems, plastering, etc.) can, as a rule, be carried out without removing the curing agent, since there are no adherence problems involved.

5.3 Pigmented products

This product group involves wax emulsions (see the corresponding description) which are provided with a white pigment (titanium oxide).

This special type of curing agent is used when a heightened lightness coefficient is required. This is a good idea, for example, with high degrees of solar radiation. The pigment obtained, by contrast with the dried emulsion, provides a white film until it weathers away. This achieves a high reflection effect of the solar radiation, and therefore reduces the temperature increase of the concrete surface.

5.4 Combination products (surface retarder)

The surface retarder also consist for the most part of wax emulsions. These additionally contain a retardant, which causes the uppermost concrete layer to harden more slowly. This means that, depending on the product and the concrete, this layer can be removed after some hours, for example with a mechanical sweeper. What remains is referred to as the washed concrete surface. This needs to be given subsequent treatment with a traditional curing agent for the remaining time of the specified subsequent treatment period.

The roughness depth depends on the composition and application quantity of the surface retarder, although the time until brushing, the concrete temperature, and the contact pressure of the brushes also have an influence. This means that no overall estimation can be given. This is usually specified by the clients, and the contactor chooses the waiting time until brushing individually, based on the parameters indicated.

5.5 Intermediate curing agents

Most curing agents can often only be applied onto a matt moist concrete surface, or only after shuttering has been removed. If they are applied immediately after the laying of the concrete, they will mix with the thin film of water on the fresh concrete surface, and the full barrier effect will not be achieved.

This is where intermediate curing agents come in. They take effect only in the first few hours after the shuttering has been removed from the concrete. They are designed in such a way that they spread over the thin water film and create a barrier layer at the water-air boundary surface, which reduces the evaporation rate. During the subsequent setting and hardening phase, the water film and barrier layer are absorbed by the capillary system of the concrete, and are available for the hydration reaction. Following this, the concrete surface can be protected with conventional curing agents.

To achieve a good spreading effect, intermediate curing agents are formulated from surface-reactive substances and the film-forming raw materials of the conventional curing agents (e.g. paraffins, polymer dispersions).

6 RAW MATERIALS

6.1 Waxes

Wax is a technological collective designation for a range of natural and synthetic substances, with the following major characteristics:

- They melt above 40 °C without decomposition
- They are already relatively low-viscous only a little above the melting point
- They are highly temperature-dependent in consistency and solubility

Depending on their origin, waxes are divided into natural waxes (e.g. plant or vegetable waxes, animal waxes, mineral waxes), chemically modified waxes, and synthetic waxes (e.g. hard waxes). They have a wide range of applications.

Dried wax is in general not classified as a water-polluting substance (AwSV – Ordinance on facilities for handling substances that are hazardous to water). This is not hazardous for human beings or the environment.

The waxes used are not subject to mandatory identification marking in accordance with the CLP Regulation.

6.2 Polymer dispersions

Polymer dispersions are colloidal stable dispersions of polymer particles in an aqueous phase.

The polymer dispersions used in concrete curing agents are predominantly acrylate-based dispersions. These dispersions are manufactured by different polymerisation processes. Acrylate dispersions are characterised by rapid drying and fastness to light. As a rule they have a solids content of about 50-60 %. After drying, the milky-white dispersions form a cohesive transparent film.
Due to their high resistance to alkalis and good adherence to moist and wet substrates, these dispersions are preferably used on fresh concrete. The dispersions are further characterised by the fact that they are universally paint-compatible.

The polymer dispersions used are not subject to mandatory identification marking under the CLP Regulation.

6.3 Emulsifiers

These are what are referred to as boundary-surface active substances. This is a designation for chemical compounds which from their dissolving accumulate substantially at boundary surfaces, and thereby reduce the boundary surface tension. This makes non-mixable fluids (e.g. wax / water) mixable; in other words, an emulsion is formed. In this case, a tenside has the effect of an emulsifier.

The number of tenside types available is very great. Tensides can be of natural, partly synthetic, and fully synthetic origin. As well as this, they can be divided into the effect classes of anionic tensides, cationic tensides, non-ionic tensides, and amphotensides. The areas of application of tensides and emulsifiers respectively are extremely varied, and must be taken into account in the formulation of emulsions. Most tensides have a harmful effect in the longer term on aquatic organisms, which leads to a WGK 2 classification. Some tensides, however, are classified as WGK 1. Almost all tensides are rapidly biodegradable.

The emulsifiers used are predominantly subject to mandatory identification marking under the CLP Regulation.

6.4 Pigments

Pigments are substances which provide colour, and have a good covering capacity. By contrast with paints, they are insoluble in the system used. The colouring effect is produced by absorption and remission (scatter and / or reflection) of certain specific frequency portions of visible light. In the case of pigmented curing agents, as a rule, titanium dioxide is involved as a white pigment. It belongs to the group of inorganic pigments, and is synthetically manufactured. Due to its chemical resistance and covering capacity, it is the most frequently used white pigment worldwide.

On the European level, there is at present discussion regarding a recommendation by the Risk Assessment Committee (RAC) regarding the classification and identification marking of titanium dioxide in the carcinogenic Category 2. The consultation procedures in this respect have not yet been concluded. The pigments used are exempt from identification marking under the CLP Regulation.

6.5 Retardants

These are, as a rule, inorganic (e.g. phosphates) or organic (e.g. saccharose) substances. The retardants used are exempt from identification marking under the CLP Regulation.

6.6 Biocides

In the manufacture of curing agent emulsions it is absolutely essential to use a biocide as a conservation agent in order to provide microbial protection for the aqueous emulsion against bacteria, yeasts and fungi. The conservation agent and the active substances used in it are subject to the provisions and stipulations of the European Biocidal Products Regulation (BPR). The quantities used, depending on the emulsion type, amount to 0.05-1.0 %, related to the overall formulation. Due to the CLP Regulation, the criteria have changed for the supplementary identification marking of mixtures which contain the sensitising substances in low concentrations. It may therefore be necessary for curing agent emulsions to be identified as from 1 June 2015 with the EUH Clause 208: "Contains (name of sensitising substance), can incur allergic reactions".

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8 EPILOGUE

This 1st Edition of the Information Script "Concrete Curing Agents" was prepared by the Project Group 2.6 "Curing Agents" (PG 2.6) and discussed and adopted by Expert Committee 2 "Concrete Technology" (FA 2). The purpose of this Information Script is to provide information to all member companies as well as the interested public. All of the documents submitted by the end of March 2018 were integrated into this report.

Members of the Project Group 2.6 "Curing Agents":

Dipl.-Ing. Petra Fischer
Deutsche Bauchemie e. V., Frankfurt

Julia Hillenbrand
Sika Deutschland GmbH, Leimen

Dipl.-Ing. Ingo Husmann
Ha-Be Betonchemie GmbH & Co. KG, Hameln

Dipl.-Ing. (FH) Bernd Ising
MAPEI GmbH, Großostheim

Dr. Wolfgang Leite
GCP Germany GmbH, Lügde

Harald Nawroth
MC-Bauchemie Müller GmbH & Co. KG, Bottrop

Dr. Martin Schnalke
BASF Construction Solutions GmbH, Mannheim

Deutsche Bauchemie e. V. would be pleased if you would share your experience regarding this Information Script and invites you to make comments which should be directed to the main office in Frankfurt.

Deutsche Bauchemie e. V.
Mainzer Landstrasse 55
60329 Frankfurt am Main
Telephone +49 69 2556 - 1318
Telefax +49 69 2556 - 1319
www.deutsche-bauchemie.com

DEUTSCHE BAUCHEMIE