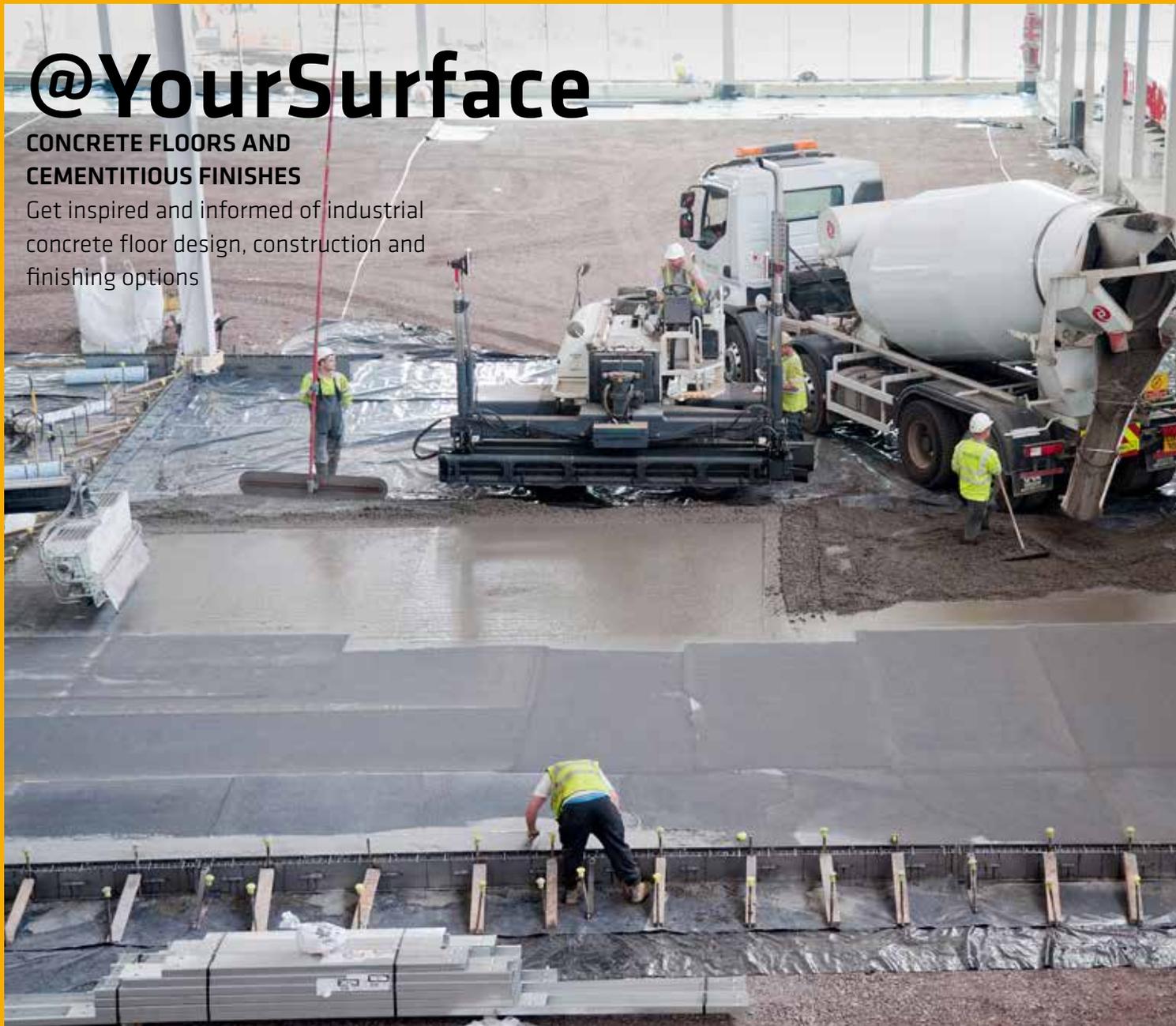


@YourSurface

CONCRETE FLOORS AND CEMENTITIOUS FINISHES

Get inspired and informed of industrial concrete floor design, construction and finishing options



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THE FINISH LINE



In this issue we discuss CONCRETE FLOORS AND CEMENTITIOUS FINISHES. We're pleased to present information about important issues related to this subject, and at the same time showcase how Sika helps owners, designers and project managers select and install the right floors and cementitious finishes.

Concrete is the mostly used construction material in the world and the most commonly used industrial floor surface. When not used as the final finish, concrete floors are used as the base slab for most commercial and industrial floor finishes. Concrete is uniquely positioned to provide the greatest durability and versatility relative to cost.

One of the most critical steps in preparing a new construction facility or renovating/repurposing a building is the concrete floor. Failure to provide an appropriate work surface can adversely affect the profitability and safety of the business operations. In addition to the predictable wear due to constant traffic, floors must withstand impact from a variety of objects, chemical exposures that vary by use, temperatures that can change rapidly and to extremes, and vibrations or movement due to operation or environmental conditions. Most importantly, the floor must be designed to be safe for employees and equipment meeting the conditions of the operation. The floor must be designed to meet these performance demands for the long term. Floor failures not only represent potential safety concerns, they can also shut down operations, or create product loss.

Although widely used, the design, installation and finishing of a first-class concrete floor is not easy. This discussion presents key factors for concrete mix design, installation layout, site conditions, floor subgrade preparation, placement workmanship, joint design and placement, finishing, concrete curing, and the environment which all impact the quality of the concrete floor installation. Other cementitious finishes and products are reviewed for repair, overlays, screeds, hardeners, and colorants. Specialty accessories can simplify and improve the installation process including: joint solutions, coloring, curing mats, etc. Specialty applications or design requirements can require higher degree concrete performance and installation skill.

Sika provides a full range concrete and cementitious products and accessory products to help you design, install and finish a concrete floor that is best for your application. Our support team is available to help you through the construction process.

Thank you for reading.

Sincerely,

A handwritten signature in black ink that reads "Ari Tantt". The signature is fluid and cursive, with a long horizontal stroke extending to the right.

Ari Tantt
Market Development Manager
Target Market Flooring
Sika Services AG



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IMPRINT

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CONSTRUCTION OF A FLOOR SLAB ON GROUND – A CHECKLIST

Concrete is by far the most used construction material in the world. Millions of square meters of concrete floors are finished every day. Because of all the experience, knowledge and developed equipment, should we be able to build and finish error-free concrete floors without cracks and with perfect flatness? Sure, in most projects the finished floor is acceptable, but failures frequently occur, often avoidable, causing nonfunctional floors and unsatisfied customers.

Constructing a first-class concrete floor is not simple. Success is influenced by many factors throughout the process of design, placement and finishing including: ground conditions, loading, concrete mix design, aggregate blend and quality, reinforcement, site conditions, concrete placement and finishing timing and methods, and curing process to mention a few. Experienced and skilled contractors cannot finish a top-class concrete slab with a poor concrete mix and vice versa. It all has to fit.

In the following checklist will be discussed some of the most important factors causing problems in placing concrete floors and how to avoid them.

SUBGRADE

The structural integrity of the subgrade beneath a ground-supported-slab is of vital importance to the long-term load bearing capacity and serviceability. Actually, concrete floors do not usually require strong support from the subgrade because the loads are distributed across





a rather large area and the pressure is usually low. However, problems occur when the subgrade settles differentially or voids under the floor slab are present and the support to slab is not uniform. Differential settlement can cause slab cracking. Settlement of the subgrade becomes a major issue with increasing loads from material handling equipment, racking and machinery.

With critical soil types, like clay and silt, simply testing the subgrade integrity is not an adequate measure. It is also

important to model the settlement behavior of the ground. Materials closer to ground surface have more effect on the measured subgrade properties than those at larger depths. Many times, it is required to use a compacted fill material on top of the subgrade layer. This provides uniform support without any soft or hard spots under the slab. Unstable geotechnical conditions may require piles-supported slab instead of directly on-ground-supported slab, which costs more but can prevent surprises and costly repairs.

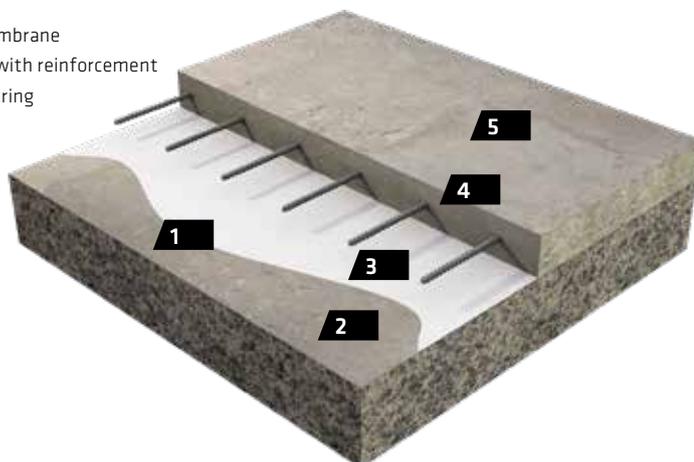
SUBBASE AND BASE COURSE

A subbase has three main purposes: to provide a working platform for construction activity, provide a level surface for the construction of the floor slab, and transmit the load from the slab to the subgrade. They are usually constructed from stable, well-graded, compacted granular material, minimum 150 mm thick.

A base course on top of the subbase makes it easier to get to the proper grade and to get it flat. By using sort of a choker course of finer material on the top of the subbase, it will support the people and equipment during concrete placement. It will also keep the slab thickness uniform, which will save money on concrete – the most expensive part of the system.

TYPICAL GROUND-ON-SLAB STRUCTURE

- 1 Subgrade
- 2 Subbase
- 3 Under slab membrane
- 4 Concrete slab with reinforcement
- 5 Topping and curing



UNDER SLAB MEMBRANE

The main purpose of the under slab membrane is to minimize the transmission of water and water vapor from the soil support system to the concrete slab and reduce the friction between the slab and the subbase. Membranes are typically plastic sheets with a thickness of not less than 0.25 mm. Reinforced membranes are used to prevent damage and punctures during the concrete placement process. Membranes should be overlapped at the edges by at least

300 mm and sealed. Incorrect or sloppy installed membrane can cause the concrete to crack or present moisture related issues in the final floor.

SERVICE CRITERIA AND DESIGN

Concrete slab on ground design comprises two main parts: first understanding the service and performance requirements of the user and operations, secondly definition of the slab thickness, reinforcement and details.

Many times, concrete floors are specified using the same serviceability criteria as concrete foundations. However, the service and stresses in floors require additional considerations. Floor design also includes focus on minimizing the potential of cracks, maximizing an abrasion resistant surface, placement and design of joints, as well as, defining the flatness and levelness of the floor.

It is crucial to get the right flatness requirements for racking and vehicle traffic patterns on the floor. For example, incorrect flatness requirements in a semi-automated VNA (Very Narrow Aisle) warehouse, can cause very costly grinding works and delays afterwards.

Slab thickness and reinforcement are strongly connected in load distribution capacity but also joint spacing. Thin slabs curl more causing larger joint openings and increasing the risk of joint spalling. Thicker slabs provide additional stiffness (cohesive strength) reducing cracking from deflection. Thicker slabs can also reduce the amount of reinforcement required. Depending upon the floor finish, concrete joints may require armored edges in heavy trafficked areas.

CONCRETE MIX

Concrete is the most critical material in a concrete floor and to get it right has the greatest impact on the floor success. The magnitude of the drying shrinkage in concrete is affected by the water content in the mix. More coarse aggregate and less water mean less shrinkage (thus,

less cracking) in the concrete. The type of cement and cement content have very little effect on drying shrinkage.

It is important to remember that every concrete plant all over the world is unique, having its own operation and using local raw materials. Therefore, writing and following a detailed prescriptive mix design in the early phase of the project can create problems. For a good concrete floor, it is important to manage the concrete strength, workability and set times. Before fixing the final concrete mix, it is highly recommended to involve and consult with all of the project participants: floor contractor and finisher, engineer, concrete supplier, material supplier and main contractor.

CONTROLLING CRACKS

Most cracks in concrete floors are the result of three actions: volumetric change

due principally to drying shrinkage, direct stress from applied loads, flexural stress due to bending. Cracks can be the net result of all three and can appear at any time and any place where the stress within the concrete exceeds the cohesive strength of the concrete. However, in reality the main reason for early stage cracking in concrete floors on-ground is drying shrinkage and the restraints.

Crack controlling measures include joint positioning and construction, as well as slab dimensions and reinforcement. These are interlinked, and the building layout and space dimensions have a huge influence.

Drying shrinkage is an unavoidable property of concrete and it is important to let the slab "slide" on the sub-base and limit the stress caused by restraint. The floor slabs need to be detached from walls,





columns, pipes and machines, which can inhibit the shrinkage movement.

In conjunction with concrete mix design, reinforcement and joints are used to control cracking. Typically, the reinforced concrete uses steel mesh or fibers made of steel, nylon, or polypropylene. Mesh positioning and correct installation is crucial for effective reinforcement. Placing the mesh too high within the concrete risks cutting the mesh when the joints are saw cut. Reinforcement near the surface of the slab provides little structural benefit. Burying the reinforcement too deep or bent steel mesh, will have no beneficial effect on controlling cracks. This can happen during the placement of the concrete by the machinery used in concreting placement.

Fiber reinforced slabs are becoming popular. Because the fibers are distributed evenly in the concrete mix there is no issue with the placement. Fibers are effective in all dimensions throughout the slab, including the floor surface. Utilizing reinforcing fibers allows for increased contraction joint spacing. Depending upon the concrete mix design, however, increased joint spacing may result in larger gaps in the joint due to shrinkage. Maximizing joint spacing requires higher fiber content, high

cement to water ratio, and low paste to aggregate ratio. Water reducing admixtures are used to maintain workability and minimize shrinkage. When designing joint spacing the panel dimensions need to be close to square.

WORKMANSHIP

Placing a concrete floor is tough work, one of the hardest jobs on a construction site. Producing and finishing a top performance concrete floor meeting all long-term service demands and aesthetics requires knowledgeable and experienced professional contractors. Technologies and equipment have developed in the last few years making the placing and finishing easier and faster, but the basics remain the same.

Today most of the big contractors are using laser-guided screeds and ride-on power trowels, which increase the production quality by providing much flatter floors while making the work faster. Power floating equipment is much faster and more effective. The transition time between the troweling pans and power floating blades is more critical with this equipment.

Finishing concrete floors properly is a learned skill that takes time, practice and training. A floor finisher must know how

to use the equipment and understand the concrete basics and the influence of conditions onsite.

CURING AND CARE AFTER FINISHING

Curing the concrete has a significant influence on the strength, abrasion resistance and final quality of the wearing surface. In addition, curing reduces the risk of cracking, crazing, curling and dusting. The main purpose of curing is to maintain favorable conditions under which concrete hardens (hydrates) and continues to gain strength and wear resistance. Proper curing is especially important in concrete slabs with large exposed surface areas in relation to their volume.

Allowing a slab to dry too fast is the biggest mistake and will adversely affect the concrete floor performance. The slab should be continuously wet for at least three to seven days. After wet curing, drying should be a long, slow process. In hot climate and if the slab surface is exposed to wind and draft the surface can dry too fast.

Newly completed floor surfaces must be protected. It is advised to keep foot traffic off at least for one day, light rubber-tired vehicles for seven days. Subsequent construction activities

should not be allowed to damage the surface through neglect and carelessness. It can happen that the subsequent rack installation or other activities on the floor damages the floor before it is placed in service.

HOW TO MANAGE TO MAKE A TOP CONCRETE FLOOR?

The saying “half planned is half done” applies to concrete floor construction. Floor design must correspond to the client’s performance requirements and the specification must be detailed and realistic. Good planning applies to

construction grading, base preparation, concrete placement, finishing and curing. Floor finishing must be executed professionally with the right equipment and experienced workers. The contractor must prepare a plan for the project and have proper quality control system.

Before the project starts, it is advisable to have a team meeting with all the main project participants, including, floor contractor, main contractor, client supervisor, site engineer, architect, concrete supplier, any relevant product supplier etc. The meeting must deal

with the most critical issues of execution including: site conditions, concrete delivery, concrete mix, technical details, daily areas, execution details, curing and when the floor can be open for traffic. To make it all work, team cooperation for all participants is a must.



CHECKLIST FOR SUCCESSFUL CONCRETE FLOOR CONSTRUCTION

- Understanding subgrade conditions
- Building a solid and flat sub-base
- Installing below-slab membrane
- Understanding and specifying the final floor requirements
- Defining the concrete mix focusing on limiting shrinkage
- Defining joint spacing and joint structures
- Adequate slab thickness and reinforcement
- Professional experienced contractor
- Efficient curing with adequate time
- Protect the floor from subsequent construction activities
- Reliable material supplier with high quality products
- Team communication before and during installation

CONCRETE MIX DESIGN

Long-term concrete floor durability and functionality are affected by a multitude of variables. Concrete quality, finishing procedures, weather conditions/placing environment, joints, and subgrade to mention a few. Quality concrete is certainly one of the most important parts of the equation for durable floors. The best contractor in the world will not be able to meet the expectations without a good mix design and, on the other hand, a good concrete mix design will not overcome improper procedures at the batch plant, subgrade faults, or poor placement.

The quality of the concrete mix is a critical step to ensure proper placement, cure and ultimately the performance of the slab in its hardened state. Improving concrete mix designs is a continuous challenge for all those involved in the concrete business. In this article we discuss the issues related to concrete mix design and the influence of the mix components on production of high performance concrete slabs.

BASIC CONSIDERATIONS FOR FLOOR SLAB CONCRETE MIX

First, it is important to state that a universal concrete mix does not exist. The basics of the chemistry of cement are mostly understood, but the variations in the raw materials make 100% control of the industrial process nearly impossible.

For these reasons, controls are required for the production of cement, grading and evaluation of aggregates, selection of admixtures, monitoring the blending of these components, and ultimately placing the concrete.

Aggregates typically comprise 70% of

CONCRETE CONSISTS OF CEMENT, AGGREGATES, ADDITIVES, ADMIXTURES AND WATER.





the total volume of the materials. The amount and quality of the aggregates has great impact on the characteristics of the concrete. Additives impact the placement workability and affect the performance properties of the finished concrete. Water is required to initiate the concrete formation process, but the quality and amount of water will impact the functionality of the concrete slab.

Portland cement and similar binding materials are mixed with water to produce a paste, the glue that holds

the aggregates within concrete. This chemical process is called hydration and continues throughout the life of the concrete slab. Depending upon the chemical composition of the cement, different types of crystals (calcium-silica-hydrates) will grow and interlock. This process defines the final characteristics of the hardened slab e.g. strength, hardness, abrasion resistance, etc.

The constituents in all concrete mix designs are basically the same. However, concrete intended for floor slab applications demand some special design mix considerations. Concrete floors require a mix design that results in low shrinkage to minimize cracking and curling while maintaining the concrete strength for high abrasion resistance and high load bearing performance. The mix must also allow for ease of placement and finishing.

AGGREGATE

The type, hardness, shape and gradation of aggregates all affect the performance. A well graded and high aggregate-to-cement paste ratio will produce a high density, low porosity concrete slab. Aggregates play a large role in determining concrete's workability, ease of finishing, and degree of plastic and drying shrinkage. They also affect load

transfer at cracks and induced joints. Aggregates are divided into coarse and fine based upon sieve sizes. Coarse aggregate, also called stone or gravel, consist of particles size at least 5 mm across and maximum size of 37.5 mm. Fine aggregate, also called sand or fines, consists particles less than 4 mm across (Standard EN 206).

Coarse aggregate may consist of natural gravel or man-made crushed rock. Gravel particles tend to be smooth and rounded, making concrete that is easier to pump and strike-off. Crushed-rock particles are rougher and more angular, making concrete stronger and improves concrete interlock at cracks. Coarse aggregate plays a vital role in controlling shrinkage, a great concern in floor construction. Well graded aggregate blends minimize the voids in concrete producing a stronger and more economical mix. The content of fines is normally 35 - 45% of the total aggregate content. Higher percentages of fine aggregate results in higher amount of cement paste. This increases the workability but makes the concrete less economical and increases shrinkage and slab porosity.

Aggregate gradation determines the void content and consequently the amount of



Cut section of hardened concrete.

cement and water (paste) required to fill the void space. Aggregate grading is done through a series of sieves to generate a grading curve. The goal of the aggregate grading is to maximize the coarse aggregate, minimize voids, reduce the cement and water content, while maintaining good workability.

In practice, a single ideal gradation does not exist. Placing environments and floor performance demands require different blends and mix designs. The following list is a few considerations for aggregates selection:

- Use the largest size of properly graded aggregate available, however, if the concrete is distributed by pump, contains steel fibers, or easy smoothing properties are required select a maximum aggregate size 16 mm
- Coarse aggregate should comprise approximately 60% of the total aggregate mix
- Crushed or round aggregate can be used, however, round fine aggregates are preferred to improve workability and reduce water-to-cement ratio (w/c)

In addition to the grading of aggregate, the selection of the aggregate itself is critical to the performance of the concrete floor. Some aggregates



SLUMP TEST ON SITE

Slump is a measure of the consistency of fresh concrete. The higher the slump, the more workable the concrete. If the slump of concrete is too low, it won't shape very easily. If it is too high, you run the risk of having the gravel, sand and cement settle out of the mixture.

are expansive in the presence of moist alkaline conditions. Similar to the formation of rust on reinforcing rebar, expansive aggregates will cause the concrete to crack or manifest as "pop outs". This process is called "Alkali Silicate Reaction" (ASR). The occurrence of these expansive aggregates will vary by the geographic source of the aggregates. The aggregates should be tested prior to mix approval to avoid this potential problem.

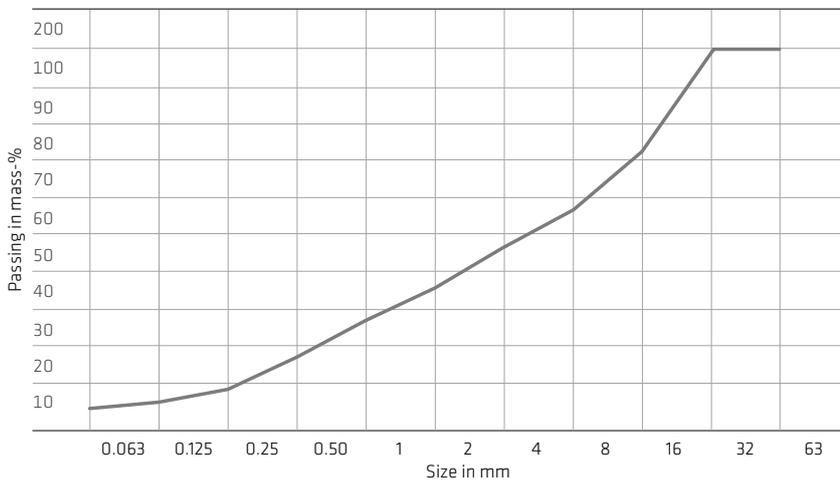
CEMENT

Concrete floor mixes typically use CEM I or CEM II Portland cement. Type I cement is recommended in winter conditions, Type II cement in summer or hot ambient temperature conditions.

In many countries the concrete mix design is trending toward lower cement content. With well graded aggregates, the strength may not be an issue but ease of finishing may become a problem with these mix designs. Proper finishing requires at least 250 kg/m³ of cement to produce a hard, dense, burnished troweled finish. Depending upon the floor environment exposure class, the typical industrial floor concrete mix contains about 300 - 360 kg/m³ of cement.

Shrinkage-compensating concrete (SCC) mixes made with expansive cement is another option. Conventional concrete shrinks during the initial drying stage and requires proper jointing to avoid random cracking. SCC initially expands, compensating for later drying shrinkage and therefore reduces the need for contraction joints.

AGGREGATE SIEVE CURVE DIAGRAM



ADDITIVES

Additives are silicate-based materials that react during the hydration of cement forming additional calcium silicate hydrate, the material responsible for holding concrete together. These additives increase the strength and density of concrete, decrease efflorescence formation and, through the incorporation of calcium hydroxide, can significantly reduce the risk of ASR.

Additives reduce the amount of cement required in the concrete mix design. Additives typically used include fly ash, metakaolin, silica fume, slag, calcined

shale, limestone powder. Fly ash is not recommended as an additive for concrete floors if dry shake hardeners are used. Fly ash takes high amount of water from concrete mix to initial hardening process and the moisture is not then available for dry shake reaction. This may lead to de-lamination of the topping.

WATER

Potable water should be used for manufacturing cementitious materials. The water-to-cement ratio is one of the key factors determining the mechanical and functional properties such as strength and porosity. Properly graded aggregates reduce the cement and water requirements. The water-cement (w/c) ratio should not exceed 0.55. The lower the w/c ratio the less water needs to evaporate. Therefore, lower w/c ratio is recommended however it is important to remember that if dry shake topping is used the w/c ratio should not be below 0.50 to secure proper wetting. In floor applications, the concrete slump should be in the range of 70 to 100 mm. Too high slump may cause segregation of the aggregates. Slump is not a true indication of the water content of a mix but on the job, it is frequently the driving force for the addition of more water. On site modification of the concrete mix must be limited to maintain the performance properties of the finished slab.

ADMIXTURES

Chemical admixtures are materials in the form of powder or fluids that are added to the concrete to give it certain characteristics to improve handling and/or performance. In normal use, admixture content is 2 – 2.5% of the cement mass. Admixtures are added into the concrete at the time of mixing and batching.

Water reducing plasticizers and superplasticizers are typically used in concrete mix designs for concrete floor slabs to adjust the consistency of the concrete. These admixtures improve the concrete strength because they reduce the amount of water required to maintain

good workability. This minimizes the water-to-cement ratio and decreases the concrete permeability.

There is no special plasticizer recommended for flooring mix design, but generally strong superplasticizer with high water reduction and extended

slump retention are not recommended because of high cement paste viscosity (“elephant skin effect on the surface”). Mid-range plasticizers or mix of mid-range plasticizers and polymers with moderate water reduction properties are a better solution. The mix design and amount of plasticizers must be adjusted

TABLE OF SIKA ADMIXTURE OFFERING

| ADMIXTURES | |
|-------------------------|--|
| Sikaplast® | Medium range water reducer |
| SikaMent® | High water reducer |
| Sika® ViscoCrete® | High range water reducer ¹ |
| Sika® ViscoFlow® | Workability enhancer |
| SikaRapid® | Concrete accelerator |
| Sika® Retarder | Retarder |
| ADDITIVES | |
| Sikafiber® | Micro / macro synthetic / steel fibers |
| SikaColorflo® | Concrete colors |
| SikaFume® | Silica fume |
| DURABILITY ADMIXTURES | |
| SikaControl® AER | Air-entrainer |
| SikaControl® Antifreeze | Cold weather |
| SikaControl® | Shrinkage reducer |
| Sika® Ferrogard® | Corrosion inhibitor |
| ESSENTIALS | |
| SikaPump® | Pumping agent |
| Sika® Separol® | Mold release agent |
| Sika® Antisol® | Curing agent |

¹ Only rarely because of the high viscosity of concrete. For advice about admixtures also contact your local Sika® technical department.

MIX DESIGN

When considering mix designs for concrete floor slabs, the expectations of the stakeholders come together to form the mix requirements:

| | |
|--------------------|---|
| Owner: | Cost, aesthetics, fastest to service, joint locations, no cracking |
| Concrete producer: | No special ingredients, production quantity, water temperature, ambient temperature, fast mixing time, transportation, timing |
| Engineer: | Design loads, slab thickness, concrete strength, exposure / durability permeability, controlling shrinkage, overlay, no cracking, |
| Contractor: | Cost effective, joint locations, consumption, placing and finishing technique, ambient temperature, workability time, easy to place, fast setting, fast hardening, curing, easy surface finishing |



according to site conditions – transport time, concrete plant capacity, slab thickness, daily finished floor area and weather conditions. Therefore, a trial concrete mix is highly recommended.

Admixtures can be used to accelerate or retard cement hydration (hardening) to accommodate varying environmental conditions during placement. Retarders are used in large or difficult pours where partial setting before the pour is undesirable; for example in long transportation time or in hot weather conditions. Accelerators speed up the hydration and are used normally in cold weather conditions.

Shrinkage reducing agents are used in situ concrete slabs to reduce drying shrinkage limiting risk of cracking and allowing increased joint spacing. Shrinkage reducing agents are also used to minimize the shrinkage between new thin bonded topping slabs applied to an existing substrate.

Air-entrainment admixtures add and distribute small air “bubbles” in the concrete and are used to reduce damages during freeze-thaw cycles and thus increasing the durability. In normal indoor applications the volume of entrapped air in the mix is 1–2%. The amount of air should never exceed 3%. Entrained air reduces the concrete strength and makes finishing more difficult.

TYPICAL CHARACTERISTICS AND RECOMMENDATION FOR INDUSTRIAL FLOOR CONCRETE

| | |
|--------------------------|---|
| Strength | min 30 MPa |
| Cement | 300 – 360 kg/m ³ (CEM I or CEM II dosage according to aggregate) |
| Sand / gravel | 0 – 16 / 22 mm (4 – 8 mm fraction low) |
| Fines | 425 – 450 kg/m ³ |
| Sand fraction (0 – 4 mm) | ≥40 % |
| Slump | 70 – 100 mm (e.g. S4 according to EN 206) |
| W/C ratio | 0.50 – 0.55 (lower w/c possible if any dry shake topping is not used) |
| Air | Max 3 % |

The mix design brings together all the requirements:

- Cement type and content
- Water-to-cement ratio
- Aggregate sieve curve
- Aggregate-to-cement paste ratio
- Admixtures
- Slump
- Density
- Air content
- Yield
- Mixing time
- Hydration heat evolution
- Workability time
- Setting and hardening time
- Surface finish
- No bleeding and segregation
- Low shrinkage
- Low permeability/porosity
- Cost

It is always recommended to make a trial batch of the mix design to check the desired properties are in accordance with the requirements.

SIKA SERVICE AND MIX DESIGN TOOL

A universal concrete mix does not exist. The proper design of concrete is critical for the production of a high performance concrete floor slab. The Sika® Mix Design Tool is a complete mix design calculator and database for raw materials to optimize cost effective mix designs. It is a useful tool for a ready mix plant when tailoring their mix design. In addition, Sika’s concrete experts assist in mix design questions and provide technical support on construction site in batching or concreting issues.



FIBER REINFORCEMENT IN FLOOR SLABS

Concrete is the material of choice for floors industrial and storage facilities around the world. It has excellent compressive strength, but is brittle in tension. To overcome this, concrete needs to be reinforced with another material to take tensile stresses.



Usually this is done with steel bars, fabric or fibers. More recent is the development of synthetic macro-fibers and other polymer fiber solutions. These methods of reinforcement influence the post cracking behavior of concrete. In order to have the material with a safe bearing capacity, a minimum quantity of reinforcement (bar or fibers) is required to guarantee the post-cracking ductility.

Reinforcement is not only required for improving the bearing capacity of the concrete slab, but also to control cracks induced by shrinkage. If the slab design has too light reinforcement, the development of micro cracks due to drying shrinkage cannot be controlled. As a result, the micro cracks join together and unrestrained shrinkage cracks develop. These can widen to the point that aggregate interlock is lost and load transfer from one side of the crack to the other cannot take place. To prevent random cracks from forming, a typical floor slab

will be designed to crack at prescribed positions (sawn induced joints). These can be regarded as "planned cracks".

FIBER REINFORCEMENT

Fiber reinforced concrete is concrete to which fibers have been added during production to improve its cracking and fracturing behavior. The fibers are embedded in the cement matrix and have no significant effect until during the hardening process they inhibit the emergence of cracks through their tensile strength and extensibility. Where there is greater strain they prevent larger cracks by causing them to dissipate into more numerous, but very fine and generally harmless ones. Cracks can occur at different times in the concrete: in the beginning during the hardening process, where it is mainly early-age shrinkage cracking; then with increasing age and hardness, stress cracks can occur from loading.

Fibers are easy to handle and dose for mixing and have a good bond in the matrix, they are ideal for improving the performance of concrete or mortar for many applications. Using suitable fibers improve significantly the properties of the floor slab concrete or screed, including:

- Less cracking due to early-age shrinkage
- Better cohesion in the fresh concrete
- Higher flexural and shear strength ("toughness")
- Improved load capacity and ductility
- Increased abrasion resistance
- Protection against freeze-thaw attack
- Increased fire resistance

Fibers are distributed in the whole concrete mix matrix and are especially effective in strengthening edges and corners where conventional steel reinforcement cannot reach.

BEST USE OF THE DIFFERENT TYPES OF FIBERS

| State of concrete or mortar | Effect / property improvement | Recommended fiber type |
|-----------------------------|---|-------------------------|
| Fresh | Homogeneity improvement | Micro-PP fibers |
| Until about 12 hours | Early-age cracking reduction | Micro-PP fibers |
| 1-2 days | Reduction of cracks induced by restraint or temperature | Micro & Macro-PP fibers |
| 28 days hardening or more | Transmission of external forces | Macro-PP & Steel fibers |
| 28 days hardening or more | Improvement of fire-resistance | Micro-PP fibers |

FIBER TYPES

Concrete has developed considerably over recent decades and fiber technology has evolved rapidly with it. Dependent on their performance different kind of fibers are added to the concrete or floor screeds. Three main used fiber types include: synthetic macro-fibers, steel fibers and synthetic micro-fibers.



Steel fibers. Typical size Φ 1.0 - 1.5 mm, length 35 - 45 mm. Dosage: 20 - 45 kg/m³.

STEEL FIBERS

Steel fibers are characterized by high E-modulus and high tensile strength. They prevent creep of the concrete but do not counter-act early shrinkage. High dosage of long steel fibers can be used in "joint-free" slab designs, when saw cut control joints are preferred to be eliminated. In suspended ground slab designs long steel fibers can replace some of the traditional steel bar reinforcement. Corrosion does not cause spalling of the concrete, just a change of color on the concrete surface.



SikaFiber® Force (synthetic macro fiber). Size Φ 1.0 mm, length 54 mm. Dosage: 3 - 8 kg/m³.

SYNTHETIC MACRO-FIBERS

Synthetic macro-fibers have a lower E-modulus than steel fibers. They are used to transfer forces in hardened concrete state. They cannot take such extreme loads like steel fibers, but they work extremely effectively in the early phases of hardening to prevent and/or reduce the size of cracks developing in the concrete. They are corrosion resistant and give the concrete greater ductility. Macro-fibers can also be used to replace some of the conventional steel reinforcement; economizing on the volume of steel and saving money.



SikaFiber® (synthetic micro fiber). Typical length 6 - 12 mm. Dosage: 0.6 - 0.8 kg/m³.

SYNTHETIC MICRO-FIBERS

Synthetic micro-fibers have similar E-modulus than synthetic macro-fibers. They are mainly used to reduce early age-age shrinkage cracking and also to improve fire resistance due to their low melting point. They improve the cohesion of concrete resulting a more stable mix and lower tendency to plastic shrinkage.

DESIGN AND CONCRETE MIX

Designers and fiber manufacturers have developed proprietary design methods which take into account the ability of composite material to redistribute stresses. The design methodology for the fiber-only systems combines the yield line theory (e.g. Johansson, Meyerhof) together with other well established elastic design theories to control the serviceability states.

A well-balanced mix design is the key factor for the optimum fiber performance. This involves; the right choice of binder and water content, the right aggregate grading curve, optimum fiber quantity and any other additives and

admixtures. The most critical factors are usually selection of the right fiber type or combination (material and size): how the concrete mix design is adapted, including fiber dosing system and timing; together with the overall mixing procedure.

The fiber dosing and mixing method has a great influence on their optimum distribution in the concrete. Macro-fibers are normally formed into bundles, which can only disperse during the wet-mixing process. Water soluble bags are used for dosing smaller quantities of fibers to prevent balling.

FURTHER CONSIDERATIONS

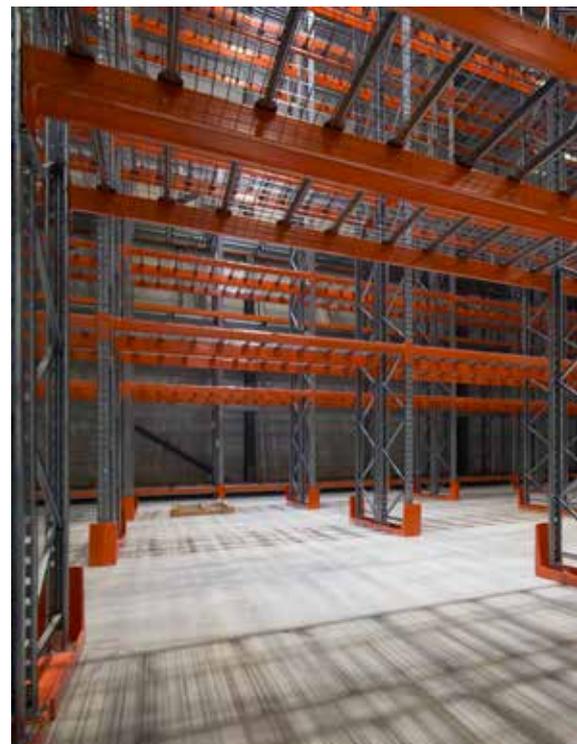
Concrete has developed considerably over recent decades and fiber technology has evolved rapidly with it. Concrete applications with fibers have expanded and new fiber materials are also increasingly capable of replacing traditional fibers such as steel and glass.

Sika's full concrete floor product offer package includes also different type of fibers allowing the engineer to select the most suitable for the project. The latest development of Sika's SikaFiber® (synthetic micro-fiber) and SikaFiber® Force (synthetic macro-fibers) complete the fiber range offering.



FIT-FOR-PURPOSE FLOOR FOR WAREHOUSING AND LOGISTICS FACILITIES - DESIGN CONSIDERATIONS

In warehouses and logistics buildings the concrete slab and flooring are critical to the effective functioning of the operations. However, it is often the perception that the concrete floor is one of the most straight forward elements of the project, and many times the overall attention paid to design and construction detail is less than proportional to its ultimate importance in the efficient operation of the facility. The expectation is that these large area floors must be constructed with lowest possible cost and provide problem free service year after year. This overview details the key issues associated with the design and construction of the concrete floor for warehousing and logistic operations.





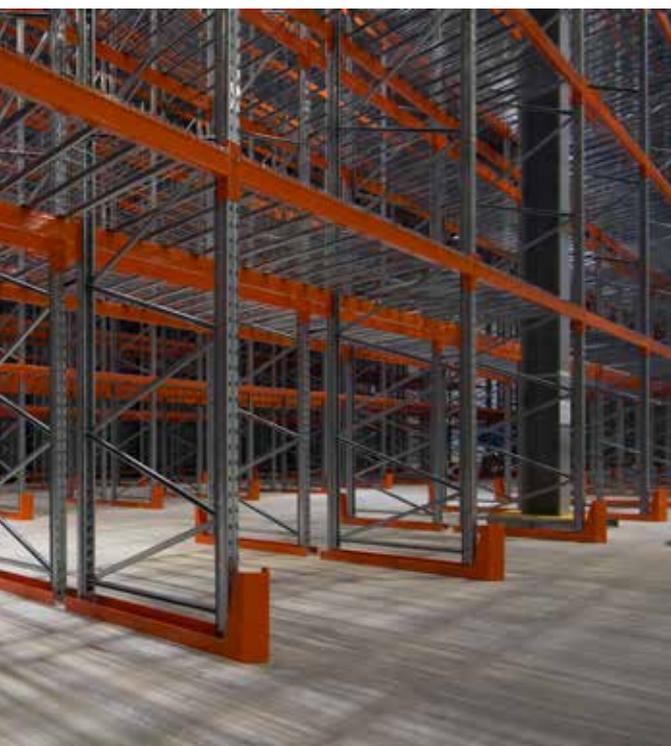
FUNCTION OF THE FLOOR SLAB

The floor slab is constructed to provide a suitable wearing surface on which the operations in the facility may be carried out efficiently and safely. In the case of ground-bearing floor slab, the concrete slab distributes the applied loads without deformation or cracking to the weaker subgrade below. Piles supporting slabs are designed as a suspended ground slabs.

These requirements may also apply to other commercial floors whether they are trafficked concrete or are finished with high performance flooring systems. The following checklist discusses some of the principle issues for consideration when specifying and designing concrete floor slabs for logistics facilities. Specific slab construction properties may differ between industries or even within the same industry. One sector, which is par-

ticularly sensitive to the need for fit-for-purpose floor slabs is logistics and warehousing with the following typical requirements:

- Support operational and stationary loads without cracking and deforming
- Minimize the number of exposed joints
- Utilize maintenance isolation joints that do not impede vehicle operating speed
- Provide a durable abrasion resistant and dust-free surface
- Appropriate levelness and flatness tolerances to support material handling systems ("MHE")
- Balance surface texture traction with cleanability
- Flexibility to accommodate possible future changes in operations
- Provide a safe and pleasant working environment



FLOOR LOADINGS

Load bearing concrete slabs-on-ground face two types of loadings: static and dynamic loadings. Static loads include for example, block stacking, equipment and machinery and storage racking systems. Dynamic loadings include material handling equipment ("MHE"), and other traffic including: forklifts, pallet stackers and other vehicles.

STATIC LOADINGS

Static loads can be divided in three different kind of types: uniformly acting loads, line loads and point loads (see the table 1).

Uniformly distributed loads are generally larger foot print distributed load, for example timber pallets or paper rolls stacked on one another. In most other commercial buildings floors are designed for nominal loading, which are substantially lower than the distributed loads in industrial areas. When machines and production equipment are installed directly on the floors, their foundation can be regarded as a uniform load. In this kind of situation, it is important to consider and dampen potential vibration.

Point loads arise from any equipment or structure mounted on legs with baseplates. Fixed conveyor systems deliver a variable point loading and require vibration consideration. The most common static point loads are from storage racking. In a conventional static racking system, the loading is transmitted to the slab through the baseplates. Baseplates have a relative small effective

contact area with floor. Most baseplates are fixed into the floor with bolts distributing the load. Different kind of racking systems include:

- Pick and deposit stations
- Mobile pallet racking
- Live storage systems
- Drive in racking
- Push-back racking
- Cantilever racks
- Mezzanines
- Clad rack structures

Line loads, as the name suggests, are loads that act along a line, for example the weight of an internal partition wall resting on a floor, calculated in units of force per unit length. Some storage systems or equipment mounted on rails are linear loads that can be placed anywhere on a floor and can be of uniform, stepped, or varying magnitude.

DEFINITION AND EXAMPLES OF STATIC LOAD TYPES (TABLE 1)

UNIFORMLY DISTRIBUTED LOAD

- | | |
|--|---|
| Load acting uniformly over relative large area | <ul style="list-style-type: none"> ■ Block stacked pallet loads and paper reels (unit loads) ■ Loads from fixed machinery and equipment ■ Nominal loadings for light commercial and recreational use |
|--|---|

LINE LOAD

- | | |
|--|--|
| Load acting uniformly over extended length | <ul style="list-style-type: none"> ■ Mobile dense racking system ■ Partition walls ■ Rail mounted fixed equipment |
|--|--|

POINT LOAD

- | | |
|---|--|
| Concentrated load from baseplate or wheel | <ul style="list-style-type: none"> ■ Arena seating ■ Clad rack buildings ■ Mezzanine legs ■ Point loads from fixed machinery ■ Stacker crane mountings ■ Storage racking legs ■ Wheel loads from materials handling equipment |
|---|--|

SURFACE REGULARITY AND FLATNESS

Surface regularity is defined and is normally controlled in two ways, levelness and flatness. Both of these factors are important to the safe, efficient and cost-effective operation of a warehouse operation. Levelness, or lack of slope, of the floor is affected by formwork, strike-off technique and the tools used. The floor flatness, or smoothness, is affected by the concrete finishing, jointing and other discontinuities. A floor may be level but not flat. Alternatively, a flat floor may not be level.

DYNAMIC LOADINGS

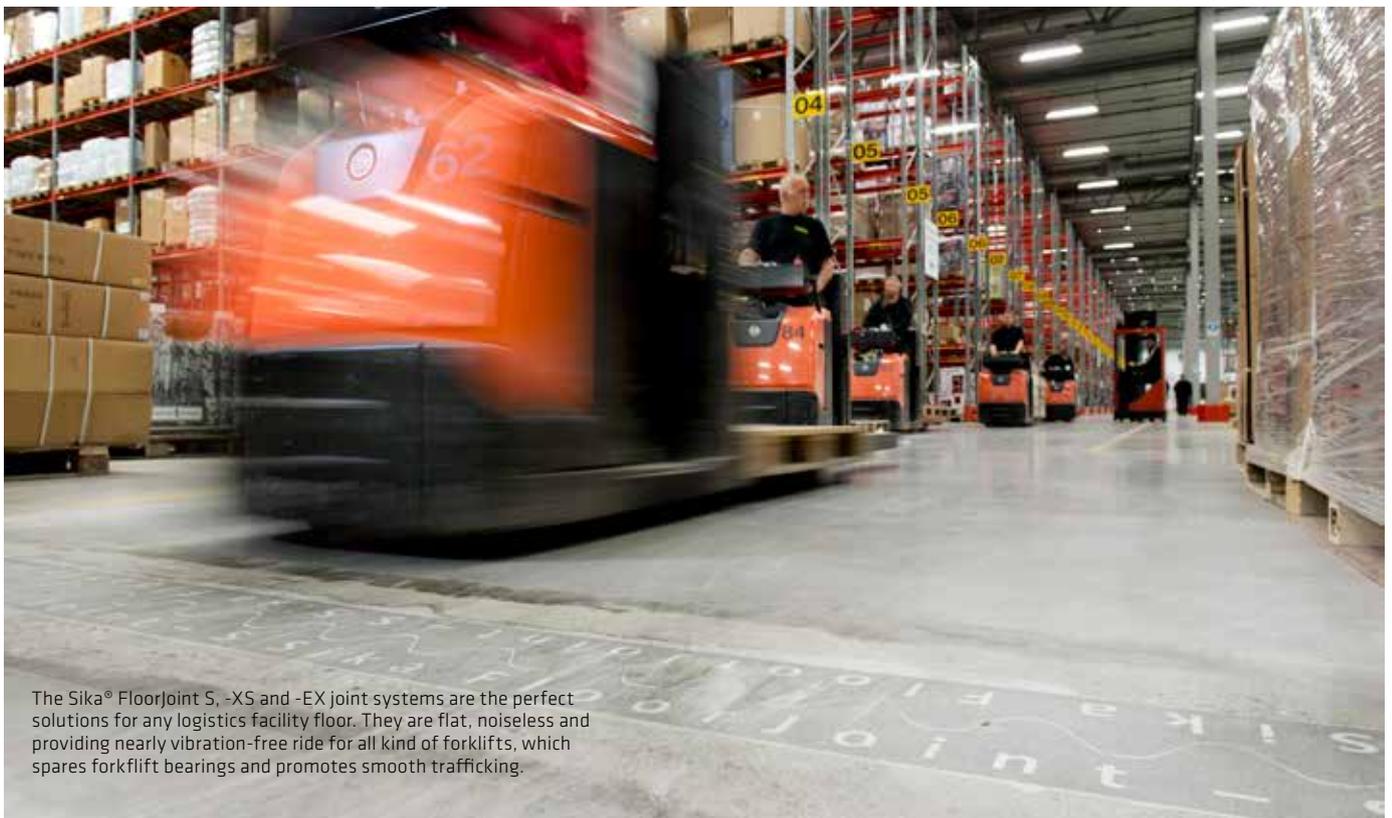
Trafficking has a great impact on the floor and its design. Material handling equipment present dynamic and point loads. Forklifts, pallets trucks and stackers move pallets and containers for bulk products or for order picking. Individual items are collected from storage, moved to packaging, and then to dispatch. Different kind of traffic can be divided by their function and type to: MHE operating in free-movement areas and wide aisles and MHE operating in very narrow aisle.

Typical vehicle operating "at floor level" is a pallet transporter, hand truck or trailer, often having maximum 3 tons capacity and small load carrying polyurethane wheels. Small and hard wheel contact surface generate high local pressure on the floor surface. Floor surfaces on which this equipment operates are typically flat and level. This light load transport equipment is commonly found in food distribution and other logistics centers. To avoid joint damage and subsequent spalling, contraction joints should be designed with narrow openings and/or filled with load bearing flexible resin to support the traffic.

Very narrow aisle (VNA) lift trucks require high flatness and levelness floor tolerances. This equipment operates in a narrow and

fixed aisle between the high racking, picking or placing pallets. The wheels of this equipment are typically hard neoprene rubber. The vehicle has a fixed path and does not usually cause extreme and aggressive abrasion to the floor surface. This truck typically has three wheels and is guided by rails at the sides of the aisle or by inductive guide wires. Floor surfaces in VNA areas should be flat and level with no wide, stepped or uneven joints. In semi-automated facilities, consideration must be given to areas where the vehicle conducts frequent turns, especially when the third wheel rotates in place.

In free-movement areas and wide aisles, counterbalance lift trucks fitted with telescopic masts (forklifts) are frequently used for material handling. The load carrying capacity can be 10 tons or more, however in industrial buildings they normally do not exceed 4 tons, depending upon the load distribution. Lift heights are limited and do not normally exceed 7 meters. The tires are either solid rubber or pneumatic, generating less surface pressure than small hard wheels. These vehicles tolerate uneven surfaces and accommodate wider joint openings than hard wheel MVE. The softer tires, however, tend to pick up debris and scrap which results in excessive floor wear due to the high abrasion.



The Sika® Floorjoint S, -XS and -EX joint systems are the perfect solutions for any logistics facility floor. They are flat, noiseless and providing nearly vibration-free ride for all kind of forklifts, which spares forklift bearings and promotes smooth trafficking.

STRUCTURAL DESIGN AND SLAB TYPES

To ensure that the concrete floor will continue to carry its design loading successfully, it is vital to design and construct the subgrade as carefully as the floor itself. Pressures exerted on the subgrade due to loading are usually low because of the rigidity of concrete floor slabs and loads from forklifts wheels or high rack legs are spread over large areas. Thus, concrete floors do not necessarily require strong support from the subgrade. However, subgrade support must be reasonable uniform without voids or abrupt changes soften support.

Subgrade soils are considered problem soils when they are highly expansive or highly compressible such as silts and clays that do not provide reasonable uniform support. Proper classification of the subgrade soil must be conducted to avoid problem subgrades. The classification report provides information for needed

subgrade improvement measures and design parameters for the concrete slab specification.

The structural design of the concrete floor slab on-ground is dominated by the sub-grade conditions and the floor loadings. The two design options are a ground-bearing slab, or a pile supported suspended slab. If consolidation of plastic soils is determined to be a potential problem a suspended slab may be the only effective solution, in which the floor slab is built on piles or between ground beams.

Both design types can be reinforced with steel mesh or fibers, or can be post-tensioned. Polypropylene macro-fiber technology is becoming more popular for ground bearing slabs.

JOINTS

Warehouses and logistic centers have a high volume of vehicular traffic. In order to maintain the long-term functionality and safe operations of these facilities, unplanned concrete cracks must be minimized and repaired, while planned expansion and contraction joints must be detailed to support the traffic. Proper design of the concrete mix, use of concrete reinforcement, satisfactory curing, and appropriate joint spacing all contribute to crack prevention. Cracking occurs when the tensile stress in a section of slab exceeds the tensile strength of the concrete. Unplanned cracks in a warehouse or logistic facility floor will quickly lead to deterioration causing safety issues and potential product damage. When cracks do occur, they must be cleaned and filled with traffic supporting semi-flexible resin.

Isolation joints design to accommodate normal structural movement are generally sealed with a highly flexible sealant. This practice will not work in warehouses and logistic facilities when the isolation joint is in a traffic pattern. A specialized joint system must be specified that will accommodate the movement and support the traffic without creating a discontinuity in the level surface.

Contraction joints, in theory, accommodate the movement created by the shrinking of the concrete slab as it cures. In practice, these joints continue to see movement due to temperature and humidity changes. These sawcut joints must be filled in areas expecting vehicular traffic. Left untreated, hard wheels will impact the joint edge leading to spalls. Similar to the treatment of cracks, traffic supporting a semi-flexible resin is used to fill these joints.



Sika's innovative joint panel system with Sika® Floorjoint XS is developed for joints with little movement and is therefore an excellent solution for bridging contraction joints.

SURFACE CHARACTERISTICS

The most important and required surface property of a warehouse floor is its ability to resist wear and dusting. Today good appearance, light reflectivity color usage for aesthetics and direction control are important considerations.

ABRASION RESISTANCE

Abrasion or wear resistance is the ability of a surface to withstand deterioration caused by rubbing, rolling, sliding, cutting and impact forces. The abrasion mechanisms will vary greatly in different applications. Complex combinations of different actions can occur, for example, truck traffic, foot traffic and scraping. Excessive and early wear can result from under specified or under strength concrete or weak surface strength related to construction conditions.

Dry Shake surface hardeners, chemical hardeners, and high-performance coatings provide cost-effective solutions to achieving a high abrasion resistance. Each of these enhances the per-

formance of the concrete floor and can meet the specifications required for specific applications.

Abrasion resistance of the floor depends strongly on the composition the concrete and the hardness and toughness of the topping material, including finish coatings. There are number of tests available to measure the wear and impact resistance. Some measure the hardness of the material itself, some the surface wear resistance capacity. Standards EN BS 8204-2:2002 and ASTM C779 and ASTM C944 give guidance on abrasion resistance, performance classes, service conditions and typical applications.

CHEMICAL RESISTANCE

Concrete is a porous material with limited chemical resistance. Organic and mineral acids react with the alkaline cementitious material eroding the surface. Many other agents, including most foods, oils, and some chemicals, attack concrete over time. Where chemical attack is likely, the floor should be protected with chemically resistant material and coating that resists the aggressive substance.

COLOR AND APPEARANCE

The final appearance of a concrete floor will never be as uniform as a coated surface finish. Concrete floors are constructed from naturally occurring materials, finished by techniques that cannot be controlled as precisely as in a factory process, and the conditions during installation will vary.

A typical concrete floor has a grey color. However, there ways to produce concrete floors with colors and provide different kind of appearances. Dry shakes hardeners containing pigment, providing a colored finish to the floor. The concrete floor can be colored by adding colorant in the concrete mix or by using acid staining or water-based dyes to provide surface color. A recent innovation uses a colored hardener in which fine pigments suspended

in water are blended on-site with liquid floor hardeners. Light color shades, like yellow, beige, light grey or even white, provide higher reflectivity and brightness in the room. This may reduce illumination requirements and save energy costs. In large warehouses this can have a big impact on the sustainability rating.

Trowel marks and discoloration from burnishing are often a consequence of the normal variations in setting of the concrete or from poor finishing, such as over-troweling. Excess curing compound can cause darker areas. These wear and disappear with the time and use of the floor without having an effect on the surface.

CONCLUSIONS

Only by providing the right combination of load carrying ability, controlling cracks, treating joints, appropriate tolerances and wearing surface performance will a warehouse floor allow the operations to be carried out as expected, with maximum efficiency and cost-effectiveness. Any defect in specification or workmanship will be exposed by the constant, demanding traffic found in these environments. Thus, the most important requirement for the floor in warehouse and logistics facilities is to provide a problem-free platform for the operations relating to functionality, durability and economy.



ULTRAFLAT FLOORS

Modern warehouse and logistics facility operators utilize higher density storage configurations to minimize land investment and optimize materials storage and handling operations. Operation automation increases material flow and turnover, through increased efficiency and productivity while reducing equipment and labor costs. In a modern warehouse incorporating automated material handling equipment (MHE) racking heights can “skyrocket” up to 20 m and the space is utilized more efficiently.





WHAT REQUIREMENT DOES AN AUTOMATED OPERATION PLACE HAVE FOR THE FLOOR AND ITS TOLERANCES?

The floors must be especially flat, smooth and level within specified tolerances to accommodate the MHE programmed movement through very narrow aisles (VNA) and the extreme heights of selecting and storing materials. Smooth, level floors without cracks, bumps and discontinuities also reduce forklift breakdowns and maintenance costs. On smooth and leveled floors the equipment can simply operate and drive faster.

OPERATIONAL ZONES

In general, there are two different types of operational zones within a warehouse: areas of free movement traffic and areas of defined-movement traffic. "Free-movement" areas are zones where vehicles travel randomly, in any direction and can have an infinite number of travel paths. "Defined-movement" areas are where vehicles travel in fixed pathways, most frequently between racks in very narrow aisles (VNA).

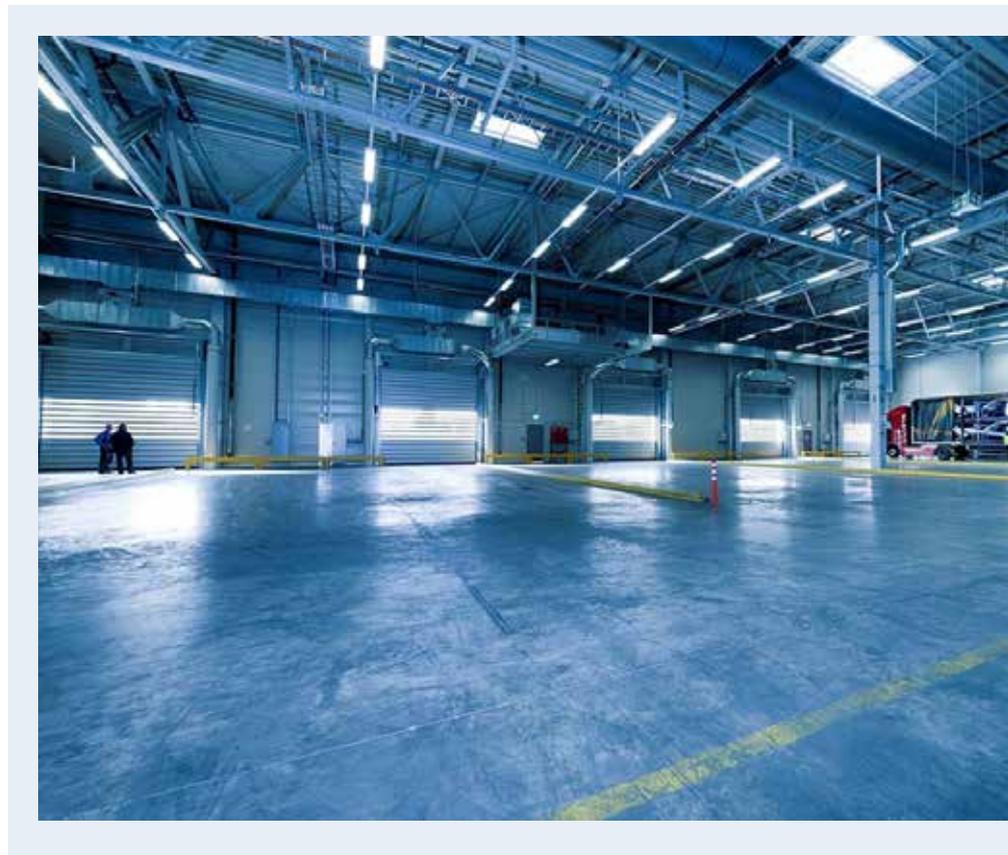
Distribution and warehouse facilities often combine these areas. Free-movement areas comprise low-activities such as unloading, packing or distribution outlets. Defined-movement areas in aisles with high level storage where forklift always follows the same path. These two uses of floors require different surface regularity specifications. Defined-movement areas cover as little as 1% of all warehouse floors but can have a decisive impact in the facility efficiency.

FLATNESS AND LEVELNESS

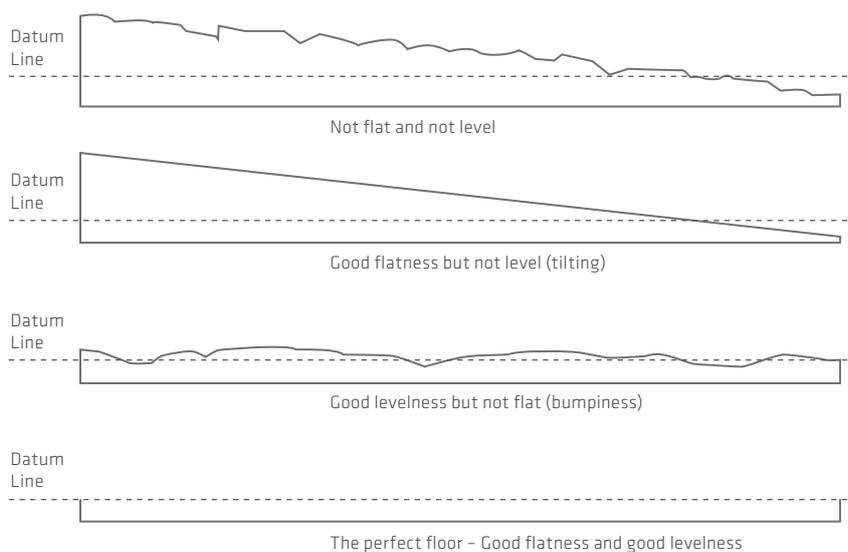
Surface regularity is defined and measured with two properties: flatness and levelness.

Flatness relates to bumpiness of the floor, a flat floor will minimize waviness and bumps. Poor flatness affects handling of the vehicles causing problems on their maneuverability and safety. The MHE must operate at reduced speeds to avoid material damage and dropped loads. Bumpy surfaces cause dynamic stresses on the bearings and suspension of the forklift.

Levelness relates to surface pitch or slope. This is measured over a longer span than flatness measurements. Elevated racking requires level floors for proper placement and retrieval of materials. Small variations in levelness of the floor surface magnify movement at the top of the forklift mast in 20 m height. Variations in the floor level also induce movements in the forklift mast



FLOOR FLATNESS & LEVELNESS



while the vehicle moves down the aisle. In narrow aisles this could result in catastrophic damage to both the vehicle and the stored materials.

TOLERANCES AND SPECIFICATIONS

Warehouse specifications define the flatness and levelness tolerances for free-movement areas and defined-traffic areas which require ultra-flat floors. Unfortunately, it is not uncommon to see a specification for random-traffic tolerances when ultra-flat tolerances are needed.

Several instruments are available for accurately measuring levelness and flatness for free-movement-area floors, but the same methods must not be used to measure defined-traffic floors. In VNA areas, instead of random sampling, each traffic path should be directly measured using continuous recording floorprofiler running exactly in the wheel tracks. The floorprofiler measures and documents both the transverse and longitudinal elevation differences of the wheels along the entire path.

A universal measurement standard



FREE-MOVEMENT AREAS

In free-movement areas vehicles can travel randomly in any direction. These areas are typically factory floors, retail outlets, low-level storage and food distribution.



DEFINED-MOVEMENT AREAS

In defined-movement areas vehicles use fixed paths in very narrow aisles. These usually can be found in storages with high-level racking reaching height up to 20 meters. In these areas the floor tolerance requirement is high, these applications are often called “superflat”, but now referred to as “ultraflat” or VDMA floors.



AlphaPlan FloorProfiler laser guided floor tolerance surveying robot in action.

STANDARDS AND SPECIFICATIONS

There are few principle specifications, which are used to some extent across the Europe and elsewhere in the world:

- Concrete Society’s Technical Report 34 (TR 34) Free Movement and Defined Movement Tables (UK)
- ASTM F-number system (ASTM E1155) and the ACI F_{min} number system (ACI 117) (USA)
- DIN 18202 and DIN 15185/ EN 15620 (Europe and Germany)
- VDMA Guideline for Defined Movement and very narrow aisle areas (Europe and Germany)

does not exist. Sophisticated standards have been developed in the US, UK and Germany but they are not fully comparable. The specification and standard incorporated is dependent on the location of installation to insure the concrete contractor is familiar with the requirements. In addition, specifications must meet the published tolerances of the MHE manufacturer to ensure the proper operation of their equipment.

The trend within the main forklift

manufacturers recommendation is to use VDMA (Verband Deutscher Maschinen- und Anlagenbau – German Engineering Federation) Guideline “Floors to Use with VNA Trucks”. This guideline is also a basis for the upcoming EN standard for VNA areas and focuses the exact operational requirements agreed by the forklift manufacturers.

Before starting the construction all project participants should have a clear understanding surface tolerance

requirements, how they will be measured and when they will be measured. Concrete contractors prefer to measure the floor immediately after the finishing of the concrete but due to the nature of the concrete cure and the potential for movement, it is more practical to measure well after installation. Even if the floor had been finished perfectly flat, the concrete slab will “live” and the “final” flatness may vary 6 – 8 months after installation.

ULTRAFLAT FLOOR CONSTRUCTION

There are three fundamentally different approaches to construct the floor with these high tolerances:

- Construction in narrow strips, to avoid joints, with the aim of installing and finishing the concrete floor itself directly to the required tolerances
- Construction of a base concrete slab and subsequently applying a finish or overlay to achieve the required tolerances
- Construction of the concrete slab to “normal” tolerances and using grinding to achieve the desired flatness



STRIP INSTALLED CONCRETE SLAB

The first method is the most cost effective and is widely used. The success of this method depends on the concrete mix and its consistent delivery. Bleed rates, ease of finishing, setting characteristics and workability are more critical than a “normal” flooring concrete mix. One of the most important installation variables is the consistency between loads of concrete. Super-flat floors require no variation in the concrete setting properties between batch placements.

No joints can be placed in the aisleways. The joints should be located under the racking system. The preferred location for joint placement is midway between to back-to-back racking legs. Transverse saw cuts and construction joints must be avoided and do not need be armored if they are not in the traffic lanes. Drying shrinkage caused curling can render super-flat floor unusable. Transverse cracking is therefore to be expected and the slab should be reinforced against longitudinal shrinkage stresses.

An ultra-flat floor can be colored using dry shake toppings installed on fresh concrete. It is important to apply them very evenly and with care to achieve the high tolerances.

FINISHING LAYER

Separate finishing layer or wearing course is normally installed in renovation



1 Strip installed concrete slab.
2 Floor grinded to tolerances in a free-movement area.

projects, where there is surface damage or major variations in level exists. Typically, only aisle areas or wheel tracks are “up-graded”. The used products can be pumpable polymer modified cementitious overlays or screeds or resin finishes.

GRINDING

It is likely that most super-flat floors will need some grinding, even when great care is taken to achieve the tolerances directly through the casting process.

Specifications often anticipate 3 - 5% of aisle length to be ground.

More grinding is necessary if a “normal” tolerance floor is converted to ultraflat specification. Grinding can be a very cost-effective method to upgrade existing floor slabs. The modern laser guided robotic grinding equipment is very efficient and can complete 100 m² yield per day with extreme precision.

INTERVIEW



Hans Voet, General Manager.

The operation and ergonomics of any fork truck fleet are only as good as the warehouse floor. AlphaPlan's wealth of experience will deliver quality through a very scientific approach, not just by survey but tailoring the floor to the client's specific needs.

Hans Voet, General Manager, AlphaPlan

How long is AlphaPlan involved in the business with Ultra-flat floors and what is your main service?

We have been involved in high tolerance floors for some 26 years with our main service being FloorProfiler and the FloorShaver Service's.

What kind of project is typical?

Today a typical project is approximately 1,700 lin meters of FloorShaver work, with over 100 lin meters being achieved in just 1 day.

What kind of tolerances are typically required? What kind of precision can you reach?

Today the Fork Truck Manufactures within the VNA aisles require the VDMA Standard, in this case we grind 0.2 mm of accuracy or below, nobody gets closer.

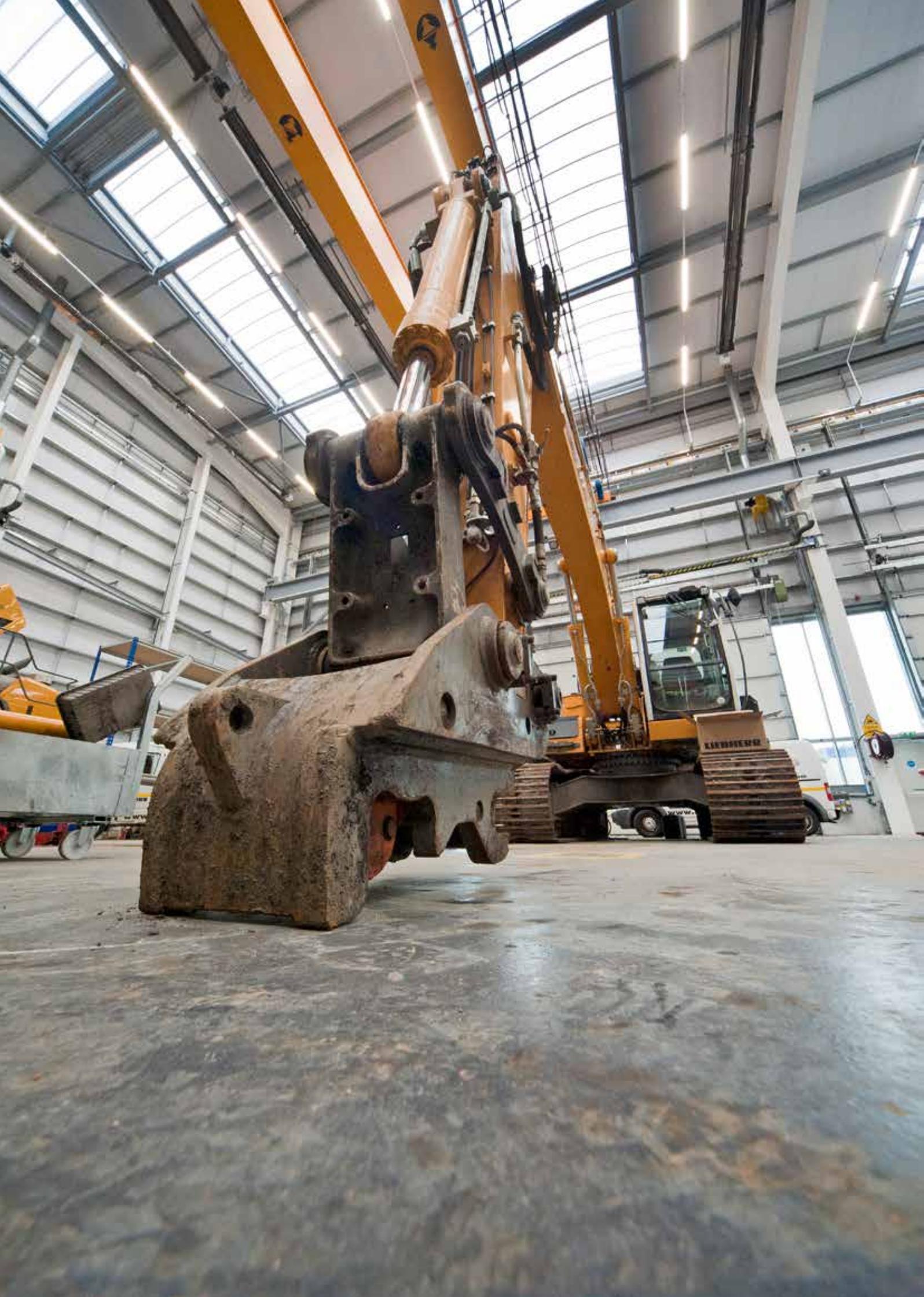
Do you see any trends in this business or are customer requirements changing?

Both.

Clients are looking for faster throughput and more stock into less of a space. This requires fork trucks to operate faster and higher, this can only mean the floors must reach the tight tolerance of the VDMA Standard. We believe this will be the case for the next 30 years.



Fast and dust-free AlphaPlan FloorShaver grinding robot producing ultra-flat floor surface.



DRY SHAKE HARDENERS

Dry shake aggregate floor hardeners are commonly applied to the surface of freshly placed concrete to improve wear resistance and occasionally to color a concrete surface. They decrease typical plain concrete negative properties like dusting and liquid absorption by improving the abrasion resistance and reducing surface permeability.

Dry shakes are factory blended materials containing a cementitious binder, aggregates, admixtures and other additives. They may incorporate inorganic pigments or be naturally colored. The ability of a dry shake material to provide a hard, abrasion-resistant wearing surface depends on the presence of enough free water at the fresh concrete surface to enable the finish to be fully wetted and worked monolithically into the base concrete. The hydration process of the cementitious material into dry shake consumes free water from concrete mix and eliminates higher water-to-cement (w/c) ration of the near-surface concrete.

WHY TO USE DRY SHAKES

All commercial, manufacturing, and warehouse floors require a high quality work surface providing long-term durability, high abrasion resistance, dust-proofing, low permeability and safety. In most industrial applications dry shake floors have the best price/performance ratio when compared with alternative concrete treatments or finishes. The main characteristics and benefits provided by dry shake hardeners include: installation time saving, enhanced durability, improved traction safety, aesthetic options, and overall economy.

Time

While dry shake is applied onto fresh concrete, the surface is finished in one step during the concreting works. The floor surface is finished together with a construction concrete slab within 8 – 12 hours after placement of concrete. The

surface is walkable after 24 hours and light operation is possible after 3 – 7 days.

Durability

The durability of a floor is the primary requirement of a quality industrial floor. In regard of dry shake hardener, the durability is determined by the abrasion resistance of the topping and its adhesion to the base concrete. The dry shake floor surface provides a tough durable cap to the concrete which is not damaged by other construction operations. The application and proper finishing of dry shake reduces the concrete porosity decreasing oil, grease and other chemical substances absorption and potential damage. High-durability concrete floors minimize maintenance and repair, operations shutdown, and overall facility costs. Due to the long life and economy of installation, concrete floors with dry shake topping deliver high performance qualifications in Life Cycle Assessment (LCA) calculations.

Safety and sustainability

The floor surface must contribute to a safe working environment in all types of operations, including wet, dry, and contaminant rich conditions. Slips and falls most frequently result from contaminants on the floor. A slip resistant floor depends upon the combination of providing a safe traction surface and an efficient maintenance routine. Floor maintenance of dry shake surfaces is easy, ordinary cleaning machines can be used. Sealers can also provide additional surface dustproofing protection making the environment hygienic and user

friendly. Dry shake applications are safe and environment friendly to install. The content of volatile organic substances (VOC) is low contributing to fire and health safety.

Economy

Dry shake floors are economical flooring solutions showing very efficient price/performance ratio. The initial material cost and reduced labor cost during construction are relatively low. Reduced maintenance cost and the long life cycle minimize plant shutdowns and lost operations costs. In total, dry shake hardeners deliver both short-term and long-term cost savings.

Aesthetics

The typical color of a dry shake floor is grey. For many years the aesthetics was considered a minority importance in industrial buildings, however aesthetics are gaining more importance due to their contribution to worker morale and corporate image. Dry shake hardeners not only deliver improved performance properties but can also contribute to the facility aesthetic design. Dry shake hardeners are available with inorganic pigments for a variety of colors, even very light color shades such as yellow and white. Light reflective floors can brighten a workspace, improve work efficiency, and reduce lighting costs. The aesthetic value of dry shake hardeners has increased trends of use in public buildings and private homes.

CLASSIFICATION OF DRY SHAKE HARDENERS

Dry shakes are divided into three basic groups according to the type of aggregate that they contain:

- Natural quartz aggregate
- Synthetic (non-metallic) mineral aggregates
- Metallic and metallic alloy aggregates

The aggregate component of a dry shake mix can range from 100 % of one of these groups to a blend of some or all of them. Blending flexibility provides options with respect to performance properties, and color. The wide range of available materials can create some confusion when selecting the appropriate dry shake hardener. The type of aggregate has an important influence on final floor appearance and performance properties, but there are no definitive international standards that specify the aggregate type or content.

The decision to specify a type of dry shake will depend on several factors, including service condition, durability, aesthetic and cost. For industrial applications, the best guide for specifiers is to compare abrasion resistance properties of the products.

ABRASION RESISTANCE AND TOUGHNESS

Abrasion resistance is the ability of the surface to resist wear caused by rubbing, rolling, sliding, cutting and to a certain extent, impact forces. Abrasion mechanisms are complex and combinations of different actions by different objects can occur in many environments - from truck tires, pallets, foot traffic and impact.

Abrasion resistance of the floor depends on the composition of the material and how it has been installed. Material hardness and toughness depends on the aggregate hardness and composition blend. Mineral hardness is measured by using the Moh Scale where 10 is the highest value as represented by diamonds and 1 is the lowest value representing the hardness of talc.



Mechanical spreading of Sikafloor®-2 SynTop dry shake hardener on fresh concrete.

For the abrasion resistance the most common testing method in Europe is described in EN 13892-4. The BCA test produces the abrasion by steel wheels at a defined load for a certain number of cycles. The maximum wear depth is measured. Based on the results of the tests the floor surfaces are classified into classes AR 0,5 - AR6 (EN 13 813). The class AR2 is usually a minimum required for industrial floors.

Another method to determine abrasion resistance is the Böhme test. According

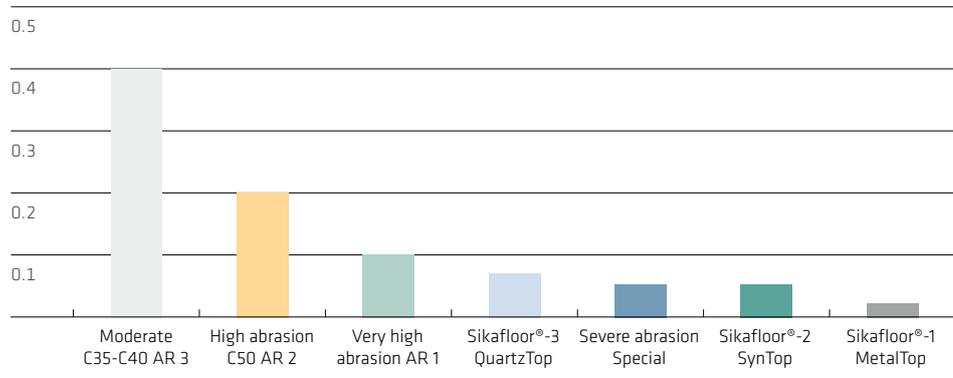
to this method (EN13892-3) the surface of the screed is pressed on to a rotating steel plate. Between the test sample and steel plate is used an abrasive sand.

The American Society for Testing and Materials (ASTM) C779 / C779M Standard Test Method for Abrasion Resistance of Horizontal Concrete Surfaces covers three procedures for determining the relative abrasion resistance of horizontal concrete surfaces. The procedures differ in the type and degree of abrasive force they impart and are intended for use in



The BCA concrete floor wear resistance test equipment according to EN 13892-4.

RESISTANCE TABLE OF DIFFERENT SIKA DRY SHAKES VS. CONCRETE



Material values in mm tested by BCA method.

NOTE: Site conditions, concrete quality and curing may influence the final abrasion values.

TYPICAL APPLICATION RATES PER END USE

| END USE | APPLICATION RATE |
|------------------------------------|--|
| Foot Traffic | 3 kg/m ² or low water cement ratio concrete |
| Light Forklift Traffic / Abrasion | 3 kg/m ² |
| Medium Forklift Traffic / Abrasion | 5 kg/m ² |
| Heavy Forklift Traffic / Abrasion | 5 - 7 kg/m ² |

NOTES:

Pigmented hardeners are recommended to be applied at a minimum rate of 6 kg/m².

Concrete may require water adjustments for higher application rates.

determining variations in surface properties of concrete affected by mixture proportions, finishing, and surface treatment.

Heavy industrial traffic and operational exposures result in more than just abrasive wear. Impacts, temperature changes, compression forces, and vibrations from various sources can

impose heavy strain. The overall toughness and the ability of the floor to withstand common stresses has a significant bearing on the floor life. Toughness can be measured as “the area under stress



Colored Sikafloor®-3 QuartzTop application.

/ strain curve” and indicates the energy absorbing capacity of the material before rupture. The compressive strength and flexural strength classes of the material give a good indication for the toughness of a floor and can be used to compare dry shake hardeners.

APPLICATION METHODS AND RATES

Dry shake hardeners are applied as a dry compound onto the fresh concrete surface, the application is achieved by hand or mechanical application. Hand application is normally completed after the initial set and floating of the concrete. Mechanical application is commonly performed immediately after concrete placement, before the initial set of the concrete has taken place.

The final thickness of a dry shake finish should be 2 – 3 mm. The necessary application rate to achieve this depends on bulk density of the dry shake. The end use of the floor and the dry shake type define the typical application rate. Variable rates can be specified in a building to suit the different uses in different places.

Mechanical application is ideal for application rates of 5 kg/m² and are not advisable for lower application rates due to the potential of the aggregate sinking into the plastic concrete slab surface. The typical application rate by hand is 4 – 5 kg/m². Higher rate is possible (up to 7 kg/m²), but it is highly dependent on the site conditions, concrete formula, and the water content in the concrete. Higher application rates by hand are best performed using two stages.

SOME DESIGN CONSIDERATIONS

Some ambient conditions and concrete mixes with low w/c ratio can make medium and high application rates extremely difficult to install and should be carefully considered during planning stages. Concrete mix w/c ratio should be at least 0.50 to secure the adequate amount of water for hydration of the hardener. Concrete mixes for interior floors should not include air entrainment and should have a measured entrapped air content more than 3%.

Dry shake hardeners are generally not

recommended for ultraflat floors. The application method and finishing process makes it difficult to achieve the critical floor tolerances required with ultraflat floors.

FINISHING REMARKS

To finish a first-class dry shake hardener floor requires strict planning, coordination and control. The concrete mix must be consistent and concrete delivery schedule to site must be controlled and continuous. The ambient conditions influence the moisture on the surface of the concrete and thus the product application and quality. The final finishing floating and power troweling procedures must be timed perfectly. Finally, proper curing of the concrete is critical to the finished properties of the slab and the dry shake hardener.

An experienced concrete flooring contractor who understands variability and details of concrete placement and utilizes the right equipment, plays an essential role in the successful installation. Professional contractors utilize a quality control system, including the placement plan and work documentation. The report should provide information of the timings, application rates and incidents in the application works.

SUMMARY

Dry shake hardeners provide an economical and durable finish for industrial concrete floors. Finishes can vary to meet performance and aesthetic requirements. As with all construction products, proper installation is critical to overall performance. Selection of the best products and installation contractor will result in a concrete floor finish that will support the operations and long-term, easily maintained, and safe work surface.



CURING THE CONCRETE FLOOR SLAB

Curing the concrete slab serves two purposes. First, it retains moisture in the slab facilitating the hydration process allowing concrete to gain strength, and second, it reduces concrete shrinkage due to evaporation until the concrete is strong enough to resist shrinkage cracking. Curing is the process of controlling the rate and extent of moisture loss from concrete during cement hydration at its early ages, so that it can fully develop mix design performance properties.

The chemical reaction of concrete hydration begins immediately when water is added to the mix design. The rate and duration of the reaction is dependent upon the mix design, temperature, humidity, surface exposure and depth of the slab. The curing process must start immediately after placement and finishing since the initial hydration of concrete develops quickly. This process decreases exponentially but will continue over the life of the slab. Therefore, industry practice is to conduct the controlled curing process over the course of three to seven days after initial placement.

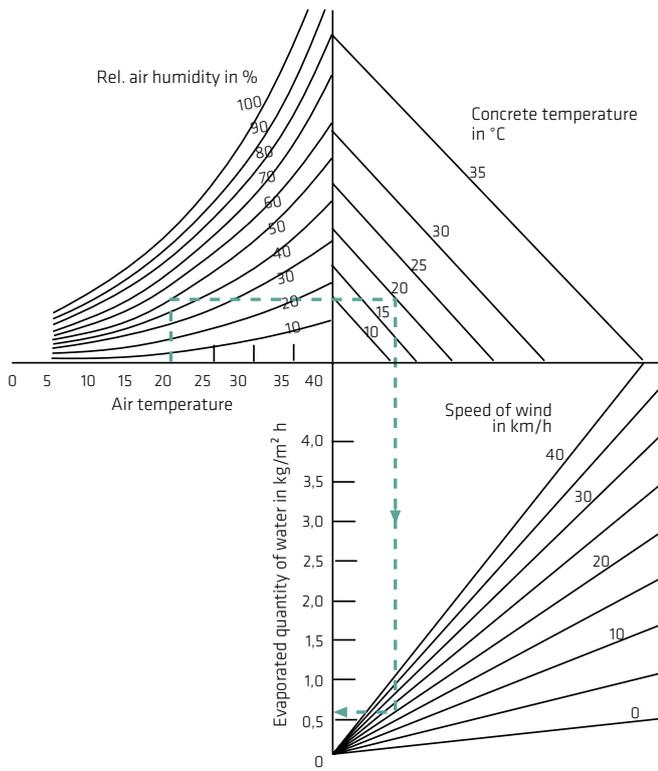
Early curing of slabs is vital to minimize the risk of plastic shrinkage cracking, especially in climatic conditions with high temperatures and strong drying winds. The curing period will vary depending on the concrete properties required, the intended purpose of use, and the ambient conditions, ie. the temperature and relative humidity of the surrounding atmosphere.

If the concrete is not properly cured and the moisture necessary for hydration evaporates too rapidly, the slab will develop cracks and will not achieve

the design strength. Using a wet curing process to maintain the moisture in the slab for the initial 7 days will result in concrete that is about 50% stronger than concrete allowed to dry for the same period.

INFLUENCE OF TEMPERATURE AND SITE CONDITIONS

Temperature extremes make it difficult to properly place, finish and cure concrete. On hot days, too much water is lost by evaporation from newly placed concrete. On the other hand, if the temperature drops too close to freezing,



This graphic shows the quantity of water which evaporates at the surface if no curing takes place. In this example there is a water loss of approximately 0.6 litres per square metres per hour (l/m² h).



Principle of effective concrete floor curing. Curing membrane reduces the water evaporation in the early-aged concrete slab.

EXAMPLE WITHOUT CURING

| | |
|-----------------------|-------------------------|
| 20°C air temperature | 20°C mortar temperature |
| 50% rel. air humidity | 20 km/h wind speed |

the hydration slows to nearly a standstill. Under these conditions, concrete ceases to gain strength and other desirable properties. In general, the temperature of new concrete should not be allowed to fall below 10 C (50 F) during the curing period.

In the worst condition of hot weather and high winds, additional precautions are recommended to cope with the fast-drying conditions. Wind shields can reduce surface air movement to minimize evaporation. Covering the slab with plastic or wet burlap will also assist in maintaining a high moisture environment. Shading can help control surface temperature variations due to direct sunlight.

CURING METHODS

After final finishing, the concrete surface must be kept continuously wet or sealed to prevent evaporation for a period of at least seven days. The earlier the curing can start the better it is for the concrete. Curing is a moisture management balancing act.

A common practice to manage moisture condition in curing slabs is to use some form of "wet curing", that is, supplying additional moisture to manage the moisture evaporation rate and the temperature of the curing concrete. There are number of methods used to wet cure and the most appropriate means may be dictated by the site conditions or the construction method.

Water retaining method

Wet burlap or cotton mats are placed on the finished concrete surface. A soaker hose or sprinkler is used to keep the mats wet. The material needs to be installed as soon as the concrete has hardened sufficiently and kept wet during the curing period to prevent surface damage. More advanced water retaining blankets systems have been developed which keep the concrete surface moist after initial wetting without need to add water during the planned curing time.

Water cure

The concrete is flooded, ponded, or mist sprayed. This is the most effective curing method for preventing mix water evaporation, but rather difficult to implement effectively. The concrete cannot be allowed to dry out between soakings and the soaking period must be time appropriate. The water used for this purpose should not be more than 5°C cooler than the concrete surface. Spraying warm concrete with cold water may give rise to "thermal shock" that may cause cracking or surface spalling.



An ultimate curing solution: Sika® Ultracure water retaining blanket system combines wet and sheet curing methods.

Liquid membrane-forming curing compounds

Curing compounds are liquids which are typically sprayed directly onto concrete surfaces and which then dry to form a membrane that retards the loss of moisture from concrete. The curing compound should be applied immediately after finishing the concrete slab. No surface water or bleed water can be present during application. Curing compounds are generally formulated from wax emulsions, chlorinated rubbers, PVA emulsions, and synthetic or natural resins. The effectiveness varies widely, depending on the material and strength of the emulsion. Curing compounds can also be used to reduce the moisture loss from concrete after initial moist curing.

Liquid applied curing compounds are an efficient and cost-effective means of curing concrete. Their efficiency is rated based upon their ability to provide a barrier to evaporation. However, they will affect the bond between concrete and subsequent surface treatments. Curing compounds frequently need to

be removed before the application of concrete coating products.

Plastic sheet covering

Plastic sheets or other similar low permeability materials, form an effective barrier against water loss, provided they are kept securely in place and are protected from damage. Their effectiveness is reduced if they are not kept securely in place or air circulates under the sheets. They should be placed over the exposed surfaces of the concrete as soon as it is possible to do so without marring the finish. In external slab constructions care must be taken that the color is appropriate for the ambient conditions. For example, white or lightly colored sheets reflect the rays of the sun, hence, help keep the concrete relatively cool during hot weather. Black plastic, on the other hand, absorbs heat to a marked extent and may cause unacceptably high concrete temperatures.

CONCLUSIONS

The importance of a proper curing process is well understood within the concrete construction industry. However, many concrete problems can be attributed to inadequate curing. Concrete performance properties are dependent upon proper curing. Engineers and architects must specify the appropriate curing method and minimum time. Construction supervisors and site engineers must ensure that curing process is executed properly, and they should provide the necessary resources to maintain satisfactory levels of curing.

Just as a new born baby comes into this world needing the utmost care for its development and protection from this new environment; a freshly placed concrete slab requires protection and care from the environment for full properties development. Strictly adopting good curing practices will help concrete achieve the designed strength properties, enhanced durability, improved microstructure, and long lasting serviceability.



THIS IS A FUN FLOOR

JOINTING PRACTICE

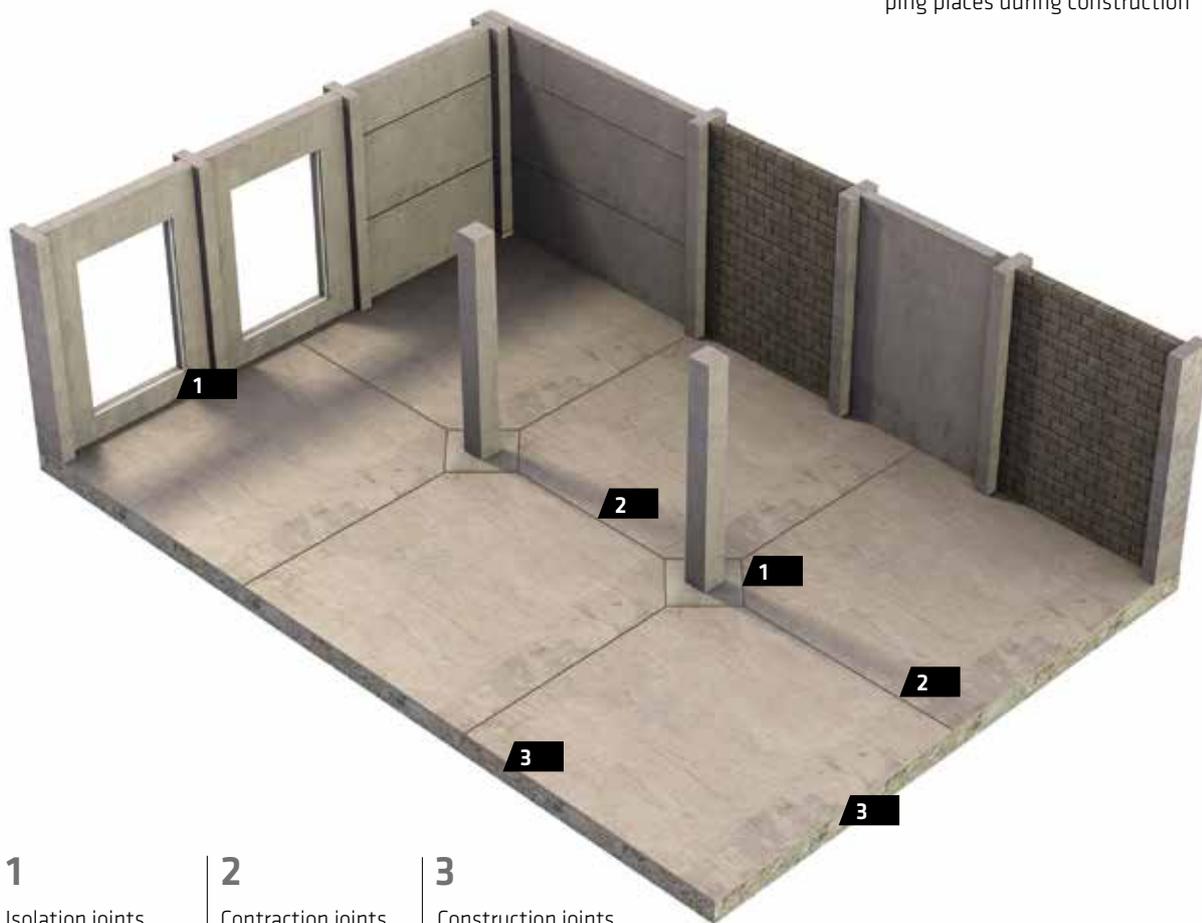
The goal of good jointing practice is to accommodate the movement in the concrete slab throughout its life, avoiding stress within the concrete that leads to cracks, and protect the joints from damage due to operational traffic.

Joints are designed into the concrete floor based upon the intended use and the traffic patterns. Three kind of joints are used:

■ **Isolation joints** (also called expansion joints) to allow intended movement between the floor and other fixed parts of the building such as columns, walls and machinery bases

■ **Contraction joints** (also called control joints) to induce cracking caused by the concrete shrinking during cure and environmental changes causing movement of the concrete

■ **Construction joints** to provide stopping places during construction



1

Isolation joints

2

Contraction joints

3

Construction joints



Within controlled environments little joint movement is expected after the concrete is cured. Wide shifts in temperature and humidity, however will create movement at these joints. When a concrete floor is to be used with no additional floor finish, it is recommended that the contraction joints be filled with a semi-flexible resin that will support traffic. This material maintains an edge-to-edge seal and supports the traffic preventing joint damage.

To do their job, contraction joints must allow the slabs to move horizontally to relieve the stresses during the curing process. In contrast, vertical movement at joints are almost always not desired. When the two sides of a joint move up and down relative to each other by more than a few hundreds of a centimeter a number of problems may occur including: joint edge cracking, expansive spalling, damage to vehicle wheels or the products they carry, and trip hazards.

Vertical movement shows up in two ways. One side of the joint is left permanently higher than the other due to curing or differential subgrade settlement. This may occur soon after placement or present itself several years later. In other

ISOLATION JOINTS

Concrete isolation joints are used to separate concrete slabs from other parts of the structure where movement is anticipated. Isolation joints allow structural members to move independently without damage. Isolation joints permit horizontal and vertical differential movement between abutting faces of the floor slab and other parts of the building. There is no keyway, bond or mechanical connection across the joint. Columns on separate footings are isolated from the floor slab either with a circular or square-shape (diamond-shaped) isolation joint pattern around the column. The square-shape is rotated to align its corners with contraction and construction joints.

Because these joints must be honored due to the potential movement, flexible joint sealants are used to prevent water, ice and dirt from getting into the joint (and into the subgrade) and to prevent intrusion from below the slab. Placement of the sealant is critical to proper function. Backer rod is placed in the joint to support the sealant and control the depth of placement. The sealant is installed at a depth of one half the joint width. A concave finish of the sealant allows for joint compression.

Where heavy traffic will cross isolation joints, provision should be made for adequate bridge the load transfer without restricting the movement. Preformed joint systems or steel edge protectors should be used to support traffic and prevent edge spalling.

CONTRACTION JOINTS

Contraction joints accommodate the initial shrinkage of the concrete slab.



Saw-cut contraction joints accommodate the initial shrinkage of the concrete slab.



Free movement joint solution from Peikko® Group. TERAJOINT® is a prefabricated leave-in-place joint system designed to build formed free-movement joints, consisting of heavy-duty arriss armoring, permanent formwork and a load transfer system. It is suitable for all large-area construction methods on ground-bearing and pile-supported concrete floors.

cases, the slab edges appear level but vertical movement is created every time a vehicle drives across the joint. When a vehicle approaches the joints, it pushes the near side down leaving the far side sticking up for the vehicle's tires to hit the edge.

MHE's (material handling equipment) with small, hard plastic tires can break the joint edge faster than soft pneumatic tires. In these applications, control joints must be filled with traffic supporting resins to prevent damage. The semi-flexible epoxy or polyurea filler is applied to the full depth of the saw cut control joint. In situations where a large crack is formed at the base of the contraction joint, sand may be used to prevent loss of material. The filler is shaved after cure to provide a level surface and complete edge protection.

CONSTRUCTION JOINTS

Construction joints usually form the edges of each day's work. Their placement conforms to the floor jointing pattern. Ideally, isolation joints can be coordinated with the daily placement terminations. When a construction joint is not intended to serve as an

isolation joint, doweling and load transfer methods must be used to prevent differential vertical slab movement and potential damage to the joint.

LOAD TRANSFER ACROSS JOINTS

Positive load transfer is key to joint stability under load and directly impacts the amount of joint deterioration or spalling. Load transfer prevents damage caused by dynamic loads traversing the joint. The ideal load transfer system is one that allows joints to open horizontally while restricting movement vertically.

There are several methods used for load transfer including; reinforcement through the joints, keyways, aggregate interlock, round dowels, fibers, and plate dowels. Some of them provide positive load transfer or allow for lateral movement between slab panels but very few do both.

Round dowels are the most widely used method and offer positive load transfer but do not allow for any movement in the horizontal plane. Round dowels need to be positioned parallel to the slab surface and at 90 degrees angle to the joint.

Accurate installation is critical to proper performance. Misaligned dowels limit movement, which may result in restraint and stress cracking.

The industry has developed a combination form and doweling system that permits concrete shrinkage, provides a leave-in-place form, and incorporates doweling for load transfer. There are several designs of these "alpha-joints" which share these features:

- 10 x 40 mm steel strips form the arriss of the joint at either side.
- A flat steel divider plate separates the slabs and mounts the dowels and sleeves in the correct position.
- The Load Transfer system (dowels and sleeves) are discrete plates, as opposed to round or steel bars – no continuous plates, as these perform poorly and are not recommended (see the Concrete Society TR34).
- Welded on Shear Studs or appendages, angled downwards and usually welded directly on to the 40 x 10 mm top steel strips.
- Plastic or nylon fixings, which shear as the slabs shrink and the joint gap increases.

CRACKS

All of the discussed jointing practices are intended to prevent cracks and concrete damage. Unfortunately, many times cracks will develop in concrete due to stress or isolated events. Cracks in concrete are unintended joints. In well-design concrete slabs these cracks are usually horizontal separations, but vertical movement may also occur due to curling or poor support. All cracks should be treated to prevent further damage. In trafficked areas, cracks are routed and leveled if necessary to provide a good bonding surface. They are then filled with semiflexible epoxy or polyurea joint fillers similar to the treatment of control joints.

HOW TO CONTROL CRACKING

A very commonly held misconception is that steel reinforcement within the slab prevents cracking. In fact, reinforcement can induce restraint stress during the normal shrinkage of concrete and therefore can actually induce cracking. It is true that if the reinforcement is correctly designed (sized and spaced), positioned accurately and supported during concrete placement, it will hold cracks tightly closed and resulting cracks will not become a serviceability problem.

In general, there are two options for controlling cracks in slabs-on-ground:

- Control the location of cracking by installing contraction joints, the crack widths will vary by the degree of shrinkage and the frequency of joint placement
- Use reinforcement to minimize the crack width, although reinforcement does not control crack location

In the first option, the saw cut contraction joint weakens the slab and encourages the crack to form within the joint. The width of the contraction joints or cracks in the joint are controlled by the joint spacing and concrete shrinkage. The greater the joint spacing and the more concrete shrinks, the greater the joint width.

Second option allows the slab to crack randomly but with steel reinforcement bars or fibers will control and limit the crack width.

Therefore, the best practice is to use both methods to minimize and control cracking. However, too much reinforcement will restrict the movement at the contraction joint. If contraction joints fail to crack and open because of reinforcement, the risk for out-of-joint or random cracking is increased.

REINFORCEMENT

Steel reinforcement bars or welded wire mesh should be positioned in the upper third of the slab thickness because shrinkage and temperature cracks originate at the surface of the slab. Saw cut contraction joints are typically cut to a depth of 25% of the slab thickness, reinforcement must be placed below this level to prevent cutting. Typical recommendation in the industry is to place the steel approximately 5 cm below the surface or within the upper third of the slab thickness, whichever is closer to surface.

Steel, nylon or polypropylene fibers, dispersed in the concrete, are another possibility to prevent uncontrolled cracking. Fibers re-distribute the stresses that occur during the shrinkage of concrete. The fibers bridge cracks that appear in concrete thereby providing a degree of post-cracking load transfer and help to prevent micro cracks from developing into macro cracks. Fibers within concrete increase the toughness and resistance to impact and fatigue loads, improve thermal shock resistance and may improve surface abrasion resistance of the slab.

GUIDE FOR JOINTING PRACTICE

- Isolation joints are dictated by the intended movement within a building and engineered into the concrete slab to accommodate continuous differential movement between structural members.
- When isolation joints are within traffic patterns, preconstructed joint assemblies must be used to bridge the load transfer and protect the concrete from damage.
- Isolation joints that do not need to support traffic are filled with a highly flexible sealant to maintain the integrity of the space above and below the slab.
- Contraction (control) joints are planned cracks which allow movements caused by temperature changes and drying shrinkage.
- Saw cut the joints as soon as the concrete is hard enough that the edges abutting the cut don't chip from the saw blade.
- Contraction joints should be initially cut 3 mm wide and 25% of the slab thickness to create a functioning joint.
- Space joints properly. Joint spacing should not be more than 24 times the slab thickness and not farther than 6 meters apart.
- Panel shape. Avoid panel shapes that exceed ratios of 1.5 to 1.
- Avoid "re-entrant" (inside) corners without associated joints. This is not always possible but planning joint pattern can sometimes eliminate re-entrant corners.
- Use proper load transfer system.
- Plan and include joint placing and reinforcement details in the floor design.
- In trafficked areas, protect joint edges with proper joint profile solutions.



TOTAL INDUSTRIAL CONCRETE FLOOR SOLUTION – THE SIKA PACKAGE

A successful concrete floor installation depends on a number of variables. Foremost, the design must meet the owner's needs and the performance requirements for the application. The installation process can be broken down into phases including grading and subgrade construction; concrete mix design and reinforcement; surface finishing; curing; and joint placement.

Each of these, separately and together, influence the durability and functionality of the final floor. Execution of the specification, workmanship and quality control during the construction process insure the success of concrete floor installation. How can Sika contribute to first class concrete floors? Sika is a global company leading the advancement of construction science through the development of construction chemicals and components. Our worldwide support team provides a complete service package with both recommended products and know-how for building first class concrete floors. Sika consults, educates and assists

owners, designers and contractors throughout the different project phases.

GET THE CONCRETE RIGHT

The first step is to optimize the concrete to meet the installation conditions, time line, and performance properties. The mix design is tailored to local cement and aggregates incorporating superplasticizer technology, e.g. Sikament®, to achieve placement workability and compressive strength while maintaining a low water-cement ratio. Shrinkage is minimized using expansive or shrinkage compensation admixtures to reduce the risks of cracking and curing. Sikafiber®

-steel or polypropylene fibers provide concrete reinforcement throughout the slab to minimize joint placement and the potential for cracking.

JOINT ARMORING AND LOAD TRANSFER

Without proper jointing, slabs could curl and crack randomly. These cracks would be subject to faulting and spalling under wheeled traffic and could become a maintenance problem. For construction joints to work properly there must be a proper load transfer so that dynamic loads can traverse them without causing faulting or impacting the joint edges. The Sika jointing systems armor and protect construction joints, reduce gaps, and prevent vertical displacement with excellent load transfer.

SURFACE HARDENERS

Concrete alone has limitations in terms of dusting, porosity, chemical, abrasion, impact resistance, and aesthetics. In order to dramatically improve a concrete

floor's lifespan it can be hardened or "armor plated", along with adding color and vitality. Surface hardeners can be a liquid chemical hardener or a powder dry-shake. Sikafloor® CureHard liquid hardeners impregnate the surface and chemically react with the constituents of concrete and improve the properties. Dry-shake hardeners are applied to new, wet concrete to form a monolithic "armored" layer on the surface, some 2 – 3 mm thick. Sika has a full range of dry-shake hardeners, from economic mineral aggregate Sikafloor®-3 QuartzTop, to ultra-high performance metallic Sikafloor®-1 MetalTop.

CURING SOLUTIONS

A properly cured concrete increases the surface hardness and abrasion resistance while reducing surface permeability, cracking, dusting, and efflorescence. Curing methods can be divided in two methods: wet curing or sprayed applied curing compounds. Wet curing keeps the surface hydrated using plastic sheets, wet burlap or special high performing curing blankets e.g. Sika® UltraCure NCF™, to minimizing the evaporation. Spray-applied curing compounds are applied to the finished concrete surface to form a membrane which reduces evaporation and facilitates proper concrete hydration. Concrete finished with dry shake hardener topping typically utilize Sikafloor® ProSeal curing compounds.

CONTRACTION AND ISOLATION JOINT TREATMENT

Exposed contraction joints and even cracks need to be filled with materials that will provide support to the edges and prevent dirt from getting into the joint. Sika flexible epoxy and polyurea joint fillers protect the joint edges while providing support for wheeled traffic.

Isolation joints require a greater degree of movement than contraction joints. Sikaflex® Pro 3 elastic joint sealant can be used to seal the floor joints. In heavily trafficked areas, the Sika® Floorjoint joint panel provides an integrated system for a vibration-free and smooth joint crossing.

FLOOR PROTECTION

Construction and jobsite traffic on the concrete floor before starting the actual operations of a facility can often be more aggressive and damaging than the operational exposure. In order to eliminate damage before floor "opening", Sika recommends the use of a floor protection board system e.g. Sika® EZcover which can also be used in combination with the Sika wet blanket curing system.

HIGH PERFORMANCE FLOOR COATINGS

A plain concrete or cementitious finish in many operational environments is simply not resistant enough to the mechanical stresses or chemical exposures

presented. A resin based high performance floor coating systems will protect the concrete and enhance the performance of floor. Sika has a complete range of seamless resin flooring products. Sika's family of flooring systems including Sikafloor® Multidur®, Sikafloor® MultiFlex, Sikafloor® Pronto and Sikafloor® PurCem® provide solutions to service areas requiring highly robust and heavy-duty systems or where more decorative and resilient flooring is preferred. These seamless liquid-applied solutions are ideal for a wide variety of applications.

SIKA SERVICE

Sika's total floor solution package covers the complete spectrum of products needs for industrial concrete floor construction. The package is delivered with Sika's highly trained and experienced professionals offering a range of value added services and support to architects, designers, owners and contractors in all project phases.

Sika's experienced experts are available to assist in design meetings, recommending specifications and product selection. Sika's technical staff supports the installation team with product training and pre-installation instructions to prevent problems and achieve quality results. Sometimes it may be beneficial to make a sample floor or test patch area to clarify that the expectations and the final floor match.

Before the project starts Sika recommends a pre-job meeting attended the owner, architect, contractors, engineers, Sika representative and other involved parties for the floor project. The pre-job meeting is intended to detail the installation specifics, clarify any issues, and discuss questions to help securing a first-class floor.





FULL CONCEPT FROM SIKA – NEW CONCRETE SLABS

| Product function | Product use | Product | Sika Product Example* |
|--------------------------------------|-------------------------|------------------------------|------------------------|
| Joint Load Transfer Systems | Joint profiles | | Sikafloor®-2 Seam AM |
| | Dowelling systems | Plate sleeves | Sika® Speed Plate |
| | | Paving Gap Seal | Sika® G-Seal |
| | | Screed edge formwork | Sika® Laser Form |
| | | Speed dowel | Sika® Speed Load |
| | | | Sika® Speed Dowel |
| Concrete | Concrete admixtures | Water reducer | SikaMent® |
| Slab and Screed Reinforcement | Slab reinforcement | PP macrofibers | SikaFiber® Force |
| | Screed reinforcement | PP microfibers | SikaFiber® |
| | Slab reinforcement | Steel fibers | SikaFiber® FE |
| Surface Hardener | Dry Shake hardeners | Quartz aggregate | Sikafloor®-3 QuartzTop |
| | | Synthetic aggregate | Sikafloor®-2 SynTop |
| | | Metallic aggregate | Sikafloor®-1 MetalTop |
| | Screed Hardener | Quartz aggregate | Sikafloor®-1+ CorCrete |
| | | Synthetic aggregate | Sikafloor®-2+ CorCrete |
| | | Metallic aggregate | Sikafloor®-3+ CorCrete |
| Liquid Hardener | | Sika® CureHard Li | |
| | | Sika® CureHard-24 | |
| Curing | Curing agents | Liquid applied curing agents | Sikafloor® ProSeal-22 |
| | | | Sikafloor® ProSeal W |
| | Curing sheet | Curing blankets | Sika® UltraCure DOT |
| | | Sika® UltraCure NCF | |
| Floor Protection | Floor protection boards | | Sika® Ezcover |
| Joints | Movement joint | Joint panel | Sika® FloorJoint S |
| | Joint sealant | PU sealant | Sikaflex® Pro 3 |
| | Backing rod | | Sika® Backing Rod |

* Please consult the local Sika representative for more details and product availability.



PROVED QUALITY AND PERFORMANCE IN CONCRETE FLOOR CONSTRUCTION

With over 20 years experience in the concrete industry, Techfloor s.r.o. has become the leading specialist in delivering high quality industrial floors in the Czech Republic.

Techfloor offers complete industrial flooring solutions for different flooring system - concrete floor, epoxy and polyurethane systems and specialty systems for food and beverage facilities.

The Techfloor team of 130 experienced and fully qualified professionals apply more than 1 mil. m² of flooring area every year.

Techfloor specializes in the construction of high quality composite concrete floors. Ground floor slabs are one of the most

important elements in the construction of modern commercial and industrial buildings. The company expertise provides their clients with the complete concrete design, placement and finishing package.

The company operates not only in the Czech Republic, but also serves a wide geographic area including Denmark, Slovakia, Poland, Sweden, Russia, Ukraine and UK. The company is fully equipped and organized for large projects like Amazon, Czech Republic

(100,000 m²); Volkswagon, Slovakia (80,000 m²); and Škoda, Mladá Boleslav, Czech Republic (300,000 m²). Techfloor has the proven capability to mobilize installations meeting rapid installation and short schedules. Average daily finished area is about 3,000 m².

The manager of concrete business, **Mr. Jiri Buksa** said about new trends in flooring business:

“Nowadays we see the trend to simplify the flooring projects and material solution. The deadlines are much tighter than 10 years ago. On the other hand, there are more investors who are looking not only for flooring technical properties, but they also emphasize the surface look and design. People are also much more interested in safety of the material and its low impact on health and environment.

In the segment of concrete industrial

floors, a seamless flooring system has been increasingly practiced in recent years, limiting the number of joints in the floor as sources of potential failures. For our company, it means to have the knowledge from different building industry areas and our continuous improvement of our management and application skills. We prefer to cooperate with only reliable partners to eliminate potential problems or claims. Reliability, competence, and our position close to our clients we see as our potential for next company development."

The company has been working with Sika since the beginning of 2010.

Mr. Jiri Buksa said:

"I really appreciate our long-term cooperation with Sika. Production of high performance and safety products is not the only reason for us to cooperate. We have to concentrate on new materials, which helps us to decrease the time of floor installation. Sika also provides us with excellent support services needed in all phases of our projects. Many times they have helped us to offer a special solution to meet the client's demand.

They help us be successful and support us if something goes wrong. Our cooperation is based on trust and strong personal connection."

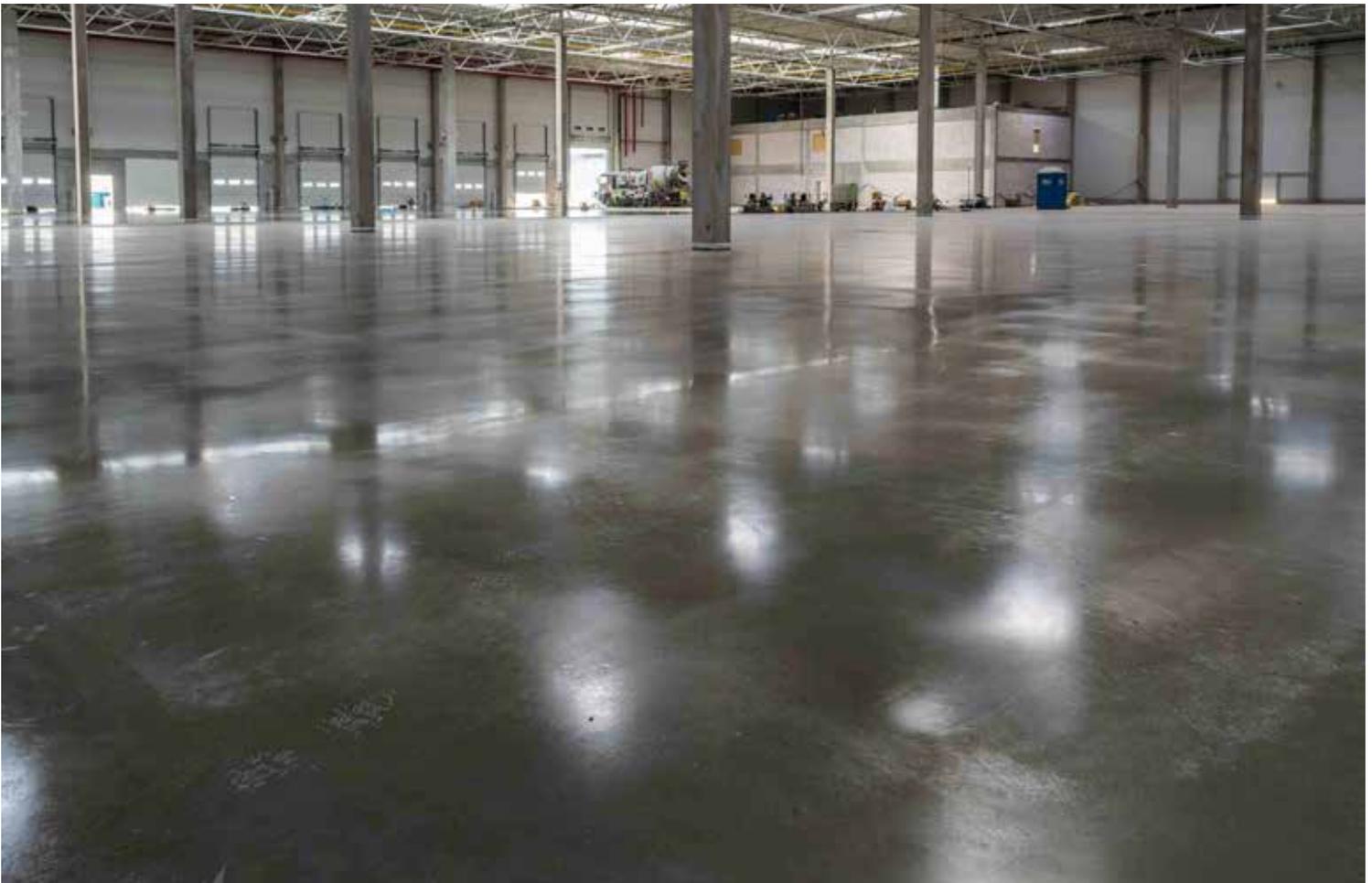


Jiri Buksa

Managing Director
Concrete Floor Division
Techfloor s.r.o.

"We have given you ideas of what opportunities are opening up to you in industrial flooring.

Of course, our work does not end but begins in this moment. The successful construction project is not only a first-class work, but also a complete service, smooth construction process and a satisfied customer. We help you choose not only the optimum floor, but also the most efficient way of realization, which will meet your technical, financial and organizational needs and expectation".



Delaminated concrete floor surface.



COMMON DEFECTS IN CONCRETE FLOORS – CAUSES AND HOW TO AVOID

Floor damages are one of the most common failures within industrial buildings. Some of the problems can occur from normal facility operations, or extraordinary use conditions. Other defects can originate from design and construction errors. Understanding and diagnosing concrete floor problems are complex and diversified because of different types of concrete and finishing, various installation conditions, usage exposures and stresses of use, resulting in a variety of damage symptoms. There tends to be a misconception that most defects are a result of poor installation workmanship. Very often the root of the problem can be found long before the placement even starts onsite including: inappropriate materials selection, including mix design, inadequate foundation and poorly controlled environment.

Before starting any remedy actions, it is crucial to diagnose the causes and thus understand the basic reason of the problem. This article primarily discusses some of the most common defects found in concrete industrial floors, but many observations and recommendations can be applied to industrial screeds and similar non-monolithic finishes.

DELAMINATION OF THE CONCRETE

Delamination of the surface generally results from closing the surface of the concrete too early. This can happen when air or bleed water is trapped below the densified surface. When dry shake floor hardeners are used, delamination can result when there is an adequate amount of water to fully hydrate the topping and thus result in a poor bond between the base concrete and the dry shake layer.

To avoid delamination problems a proper assessment of the bleed characteristics of the concrete in the environmental conditions under which the floor is being placed is critical. For example, in conditions with excess drying wind, it becomes

more difficult to determine when the concrete has sufficiently settled, and the bleed water has been released.

With dry shake application a certain amount of bleed water is necessary to ensure complete hydration. However, the timing of the application of the topping is critical; too much bleed water can cause delamination especially if finishing operation is delayed. On the other hand, delamination can occur if the concrete has reached its initial set before the dry shake has fully hydrated.

The use of air entrainment admixture slows the rate of bleed. When power-floating an air-entrained concrete slab, the surface is more easily and quickly closed. This is an ideal condition for delamination. Air content must be below 3% for all dry shakes. In indoor concrete floor mixes air entrained admixtures should not be specified. In addition, the use of supplementary cementitious materials, such as fly ash, slag, and microsilica can cause delayed bleeding and are not recommended for use with a dry shake hardener.

BLISTERING

The industry is familiar with blistering of impermeable floor coating finishes caused by moisture movement from the concrete. Why would concrete itself, a moisture permeable substrate exhibit blistering issues?

Blisters in concrete are hollow, low bumps on the concrete surface, typically size of 25 mm in diameter or even larger. They are voids under a dense troweled skin of mortar of about 3 mm thickness and may move around the surface during troweling. Blisters form on the surface of fresh concrete when either bubbles of entrained air or bleed water migrate through the concrete and become trapped under the densified surface, which has been “sealed” prematurely during finishing operations.

One or a combination of factors may cause blisters to form: excess wind decreasing surface moisture; sticky mixes or low bleed water due to air entrainment; a subgrade that is cooler than the concrete; a sticky mixture with excessive

finishes that seal the surface quickly; excessively working on the surface to produce desired finishes; finishing the concrete too early, by hand or machine; and improper use of tools; or dry shake hardener is prematurely applied. Thicker slabs and concrete placed directly on under slab membranes require more time for bleed water to rise to the surface and blisters may occur if the slab is finished too soon.

Blisters can be avoided by giving time for air and bleed water to escape before sealing the surface. Protecting the surface from excess wind helps to protect the surface from premature drying and evaporation.

DUSTING

Dusting is the development of a powdered material at the surface of hardened concrete. Dusting is a surface phenomenon of excess cementitious paste. The typical characteristic of dusting is poor surface abrasion resistance which is easily scratched and powdered. Dusting can be a result of poor curing or a high water-to-cement ratio, especially on surface. The main reasons leading to dusting are poor control of placing environment, an inappropriate mix design or bad workmanship. Excessive water applied to the surface during the floating and finishing

operations will typically result in dusting. Another cause of dusting is light freezing at the surface during the curing process.

Dusting can be avoided by using concrete mix with low water-to-cement ratio, using water reducing admixtures if necessary, and carrying out the finishing operation in an environment free of wind and direct sun. The finisher should never sprinkle additional cement into the surface to absorb free water. Excess bleed water should be removed. Curing should begin immediately after finishing utilizing curing compounds or wet curing for a minimum of 3 - 7 days.

CRACKS

Crazing cracks are very fine surface cracks, which resemble spider web or shattered glass. Often this crazing pattern is not visible until the concrete floor is wetted and begins to dry out. They can happen on any concrete slab when the surface loses moisture too quickly. Crazing does not usually affect the abrasion resistance or other wearing properties of power-troweled slabs; however, it can be an aesthetic and maintenance issue for the owner.

Crazing phenomena is significantly increased if the slab is exposed to high winds during the early stages of the

curing period. Hard steel troweled slabs frequently form craze cracks due to shrinkage of the concentrated dense surface. Any finishing operation that creates excess cementitious paste layer of the concrete surface is susceptible to craze cracking.

Another type of surface cracking is plastic shrinkage cracking. Plastic shrinkage cracks appear in the surface of fresh concrete soon after it has been placed and while it is still plastic. They are usually parallel to each other on the order of 30 to 90 cm apart and generally do not intersect the perimeter of the slab. Plastic shrinkage cracks are caused by a rapid loss of water from the surface of concrete before it has set. A critical condition exists when the rate of evaporation of surface moisture exceeds the rate at which rising bleed water can replace it, for example, high wind velocity, low relative humidity and high ambient temperatures. The best and easiest way to avoid plastic cracking is to provide a controlled placing environment and ensure that the concrete is placed and finished promptly.

Wider cracks, which can intersect the slab, can be caused by several factors including: thermal movements, drying shrinkage, loading above slab capacity, a combination of shrinkage and loading



Surface defects due to bad finishing.



Aggressive chemicals degrade concrete. The picture shows damages of chloride attack from de-icing salts.



All cracks are not the same. Before repair remedies the cause of the cracks should be clarified.

conditions. Drying shrinkage can occur over months and even years. Shrinking, in “normal concrete” is inevitable, but cracking is a result of excess stress within the slab. Crack formation during initial cure can be minimized by specification and construction of the sub-base so that the slab is allowed to freely move as it shrinks during cure.

The shrinkage characteristics of the concrete need to be taken into consideration when designing the joints spacing and determining the type and quantity of reinforcement needed to control the stress produced during cure.

SURFACE DISCOLORATION AND EFFLORESCENCE

Surface discoloration, surface defects and numerous types of “trowel marks” are mainly related to poor finishing of the concrete, poor workmanship or bad working conditions.

Surface discoloration can appear when color changes in large areas of concrete, light or dark blotches on the surface, or early light patches of efflorescence. Factors influencing discoloration can be cement alkalis or salts, non-uniform

hard troweled surfaces, inadequate or inappropriate curing, a wet substrate, variation of the water-to-cement ratio at the surface, and changes in the concrete mix between batches. Colored dry-shake applications will exhibit variable color finish due to inconsistent concrete setting and quality. An uneven concrete surface may result in variable dry shake application. It is important to apply material evenly and at appropriate coverage rates. Discoloration from these causes appears soon after placing the concrete.

Discoloration can occur at later stages as a result of any atmospheric or organic staining – simply the concrete is dirty.

Efflorescence is a powdery deposit, usually white in color that occasionally develops on the surface of concrete, often just after the floor is completed. It is caused by a combination of circumstances: soluble salts within the concrete are dissolved and migrate to the surface. The water evaporates leaving the salt deposit. All concrete materials are susceptible to efflorescence, which looks unattractive but is usually harmless and is easily removed.

CURLING

Curling is the distortion of a slab into a curved shape upward or downward bending of the edges. This happens primarily due to differences in moisture and/or temperature between the top and bottom surfaces of a concrete slab. The distortion can lift the edges or the middle of the slab from the base, leaving an unsupported portion. The slab section can crack when loads exceeding its capacity are applied. Slab edges might chip off or spall due to traffic when the edges of the slab curl upwards. This typically occurs in internal slabs.

The most common causative factor for curling is when the top surface of the slab dries and shrinks more quickly with respect to the bottom of the slab, causing upward curling of the slab edges. This is most likely related to poor curing and rapid drying but may also occur in slabs with excessive bleeding. Bleeding is accentuated in slabs placed directly on an under slab membranes or when toppings are applied on the slab. Thin slabs and wide joint spacing are more susceptible to curling. The other factor that can cause curling is the temperature differences between the top and bottom of



Non-moving crack repair. Opened crack is filled and injected by using Sikadur®-52 or Sikafloor®-156 epoxy resin.

BEFORE STARTING ANY REMEDY ACTIONS, IT IS CRUCIAL TO DIAGNOSE THE CAUSES AND THUS UNDERSTAND THE BASIC REASON OF THE PROBLEM.

the slab, e.g. on a cold night the concrete surface cools and contracts relative to bottom surface in contact with a warmer subgrade.

Suggested methods to prevent slab curling include minimize drying shrinkage, avoid the use of under slab membranes (when not using moisture sensitive floor finishes), install contraction joint spacing not exceeding 24 times slab thickness, specifying thicker slabs, insulating the concrete when temperatures drop, using properly designed and placed slab reinforcement and load transfer devices across construction joints.

JOINT DAMAGES

Joint damage is usually considered to be a major area of concern for end-user clients. The direct cause of most joint damage is dynamic loading and impact at the joints from traffic. The underlying cause is poorly detailed or constructed joint construction that is unable to accommodate these stresses. In such case, the edges of joints crack and spall.

Excessive joint opening may occur at isolation joints and at contraction joints. The reason may be a result of high shrinkage of the concrete, excessively large joint spacing, or unexpected

restraint away from the joint. In places where construction joints are highly trafficked, workmanship is important to ensure that the surface is flat and level across the joint, the concrete is well compacted and finished, and dowels or other load transfer mechanism are correctly designed and positioned.

Wide gaps in the joints expose the edges to traffic impact. Isolation joints can be designed with reinforced edges or complete prefabricated joint systems. Contraction joints can be filled with semi flexible materials to support traffic. Horizontal deviation across a joint will



FULL CONCEPT FROM SIKA – CONCRETE FLOOR REFURBISHMENT

| Product function | Product use | Product | Sika Product Example* |
|---|-----------------------|---------------------------------|----------------------------|
| Hollow subbase | Slow Fill Grout | Microfine grout | Sika® Micro Fine Grout |
| | Fast Fill | PU foam | SikaFix®-210 |
| Cacks | Injection | EP resin | Sikadur®-52 |
| Small area and spalling repair | Repair screed | Fast cementitious screeds | SikaScreed® HardTop-70 |
| | Repair mortar | Cementitious repair mortar | Sika® MonoTop-3400 Abraroc |
| | Repair compound | EP repair compound and adhesive | Sikadur®-31 |
| Large area surface repair | Repair screed | Fast cementitious screed | SikaScreed® HardTop-60 |
| | Finishing screed | Fast cementitious screed | Sikafloor®-30 Level |
| | Finishing screed | Fast cementitious screed | Sikafloor®-300 Level |
| | Screed hardener | Quartz aggregate screed | Sikafloor®-3+ CorCrete |
| | Screed hardener | Synthetic aggregate screed | Sikafloor®-2+ CorCrete |
| | Screed hardener | Metallic aggregate screed | Sikafloor®-1+ CorCrete |
| | Bonding bridge | EP bonding agent | SikaScreed®-20 EBB |
| | Bonding slab | Admixture and bonding agent | Sika® Latex |
| Polishing | Liquid hardener | Liquid hardener | Sika® CureHard Li |
| | Liquid hardener | Liquid hardener | Sika® HardCure-24 |
| | Liquid hardener | Liquid hardener | Sika® HardCure-GL |
| Joint repairs | Movement joint repair | Joint panel | Sika® FloorJoint S |
| | Induced joint repair | Joint panel | Sika® FloorJoint XS |
| | Repair compound | EP repair compound and adhesive | Sikadur®-31 |
| | Joint sealant | PU sealant | Sikaflex® Pro 3 |
| | Backing rod | | Sika® Backing Rod |
| Large area repair and protection | Coating | EP resin | Sikafloor® MultiDur |
| | Coating | EP resin | Sikafloor® MultiFlex |
| | Coating | PU hybrid | Sikafloor® PurCem |
| | Coating | PMMA resin | Sikafloor® Pronto |

* Please consult local Sika representative for more details and product availability.

result in joint damage, presents a safety concern, and may interfere with the facility operations.

Broken and spalled joints can be repaired with polymer mortars and reformed. The process is relatively straight forward but is an expense and operational disruption that can be avoided.

DAMAGES DUE TO OPERATIONS AND USE OF THE FLOOR

The damages caused by operations are typically surface damages from traffic,

chemical exposure, or impact resulting in spalls, erosion and/or cracks. Sometimes a crack in slab-on-ground can be caused by a failure of the subgrade or the ground conditions have changed after the construction. Most surface damages can be repaired with a resurfacing materials.

SUMMARY

Concrete floor repair is a complex and diversified task because of different types of floors, their different uses, and the array of damage symptoms, their causes and mechanisms. This article has

presented common causes of damages and defects, and some repair methods. In most cases, damaged concrete floors can be repaired. However, some damages require replacing the substrate and reconstructing the floor. Sika has knowledge, experience and solutions to help you design, install and maintain your concrete floors.

FAST REFURBISHMENT OF A WAREHOUSE FLOOR – DELAMINATED DRY-SHAKE FINISH

PROJECT DESCRIPTION

The newly built logistics warehouse of 2,200 m² initially had a monolithic mineral aggregate dry-shake floor finish installed with the concrete slab as the floor finish. Shortly after installation, about 3 mm of the surface layer began to delaminate over a large part of the warehouse floor. The investigations of engineers at Forensic determined that the

delamination was due to an excess dry-shake material being applied during the concreting work. It was determined that the topping needed to be removed and replaced. Complete reworking the initial specification would require the removal and replacement of the concrete slab. The extreme cost and schedule delays prohibited this option. Renovation was the only option.

PROJECT REQUIREMENTS

As this was effectively an unplanned floor renovation in a new warehouse, any delays in opening the facility for operations created a financial burden to the owner. The floor repair and replacement system had to be quick and the resulting floor finish had to meet the performance requirements and the expectations of the owner. The poorly bonded dry-shake



Delaminated dry shake hardener floor after substrate preparation.



finish needed to be completely removed by scarifying and blast cleaning. This process leaves an open textured, porous and lightly profiled surface. The replacement system had to fill any voids and defects in the substrate, and effectively resurface the concrete slab. The finished floor elevation had to be maintained, therefore the maximum thickness of the repair material allowed was only 10mm. The new replacement flooring system had to be abrasion and impact resistant to withstand the daily demands from forklifts and other heavy loads, as well as meet the specifications for flatness and levelness. The Owners and their Architects also required the overall visual appearance to be uniform.

SIKA SOLUTION

A SikaScreed® HardTop System was selected to provide an ideal solution for the floor. The system included an epoxy based SikaScreed® HardTop-BB20 bonding agent and SikaScreed® HardTop-60 fast curing and high strength cementitious polymer modified screed topping. The solution was able



SikaScreed® HardTop-60 system requires profiled substrate. Concrete substrate was profiled accordingly by using an HTC grinding machine equipped with its special bush hammering tool "HTC Ravage".



SikaScreed® HardTop repair screed system enables fast application. While in the back the team is still placing the screed, in the front the power floating can start in 90 minutes.

to bridge and fill small cracks, level the abraded surface profile, and bond to the existing concrete slab to deliver a rapid-hardening floor system. The SikaScreed® HardTop-60 surface was levelled and smoothed several times by power float finishing. The finished surface was sealed with Sikagard®-915, a stain protection impregnation sealer. The finished floor was a highly wear and impact resistant, perfect for the logistics warehouse. The surface impregnating sealer ensured

a uniform surface color, satisfying the visual requirements of the Owner. The Sika flooring system and the certified installation contractor were able to meet all the demanding requirements of the refurbishing project and deliver a cost effective, practical, and timely solution for the architects and owner.

SikaScreed® HardTop-BB20 epoxy based bonding agent ensures an excellent screed adhesion to substrate.



Hard wearing flat floor surface. After power floating the surface was treated with Sikagard®-915 stain protection and impregnation sealer.

CEMENTITIOUS FLOORING FINISHES ON CONCRETE FLOORS

New or existing concrete slabs frequently require additional surface treatment in order to improve the floor's performance properties or enhance the aesthetics. This article focuses on cementitious finishes, their methods of application and factors influencing the selection.

CEMENTITIOUS FLOOR SCREEDS, TOPPINGS AND SELF-LEVELLING OVERLAYS

In general, cementitious floor finishes have some clear advantages. They are environmental friendly, with zero VOC rates, they can be applied on substrates with high humidity and are economical. In many cases, they have high mechanical strength improving the performance and life of the concrete floor. However, it is important to remember they have limitations, this especially in harsh service environments with chemical exposure from the operations or the hygienic cleaning regimen. High performance resinous coatings and other finishing solutions may also be used to meet the performance and aesthetic requirements.

Throughout the industry the terminology used to define cementitious floor finishes varies. For the purpose of this discussion the following terms are defined:

- A "Topping" is a surface finish compound composed of a specially blended aggregate mixed with water and applied by hand or mechanically to fresh or hardened concrete.
- A "Screed" are generally much thicker than toppings and may be the finished surface or provide a smooth, level surface for subsequent floor finish treatments.
- Self-levelling overlays are polymer-modified cementitious compounds, which can act as a final finish or as an underlayment.

TOPPINGS

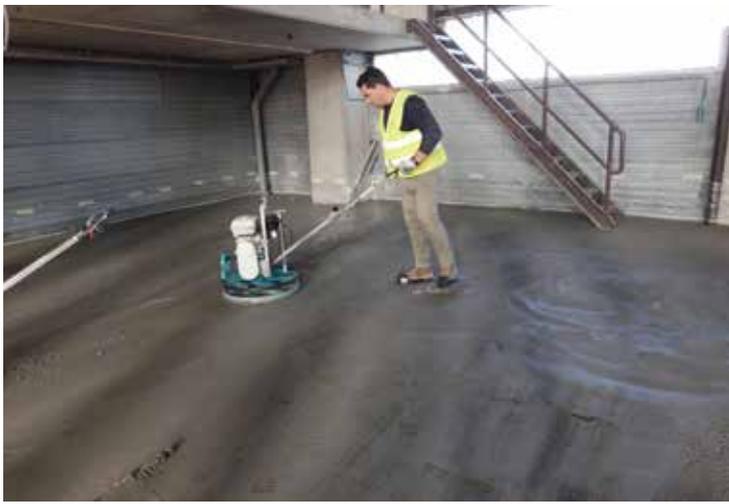
Toppings are typically used to provide industrial floors heavy-duty abrasion resistance. The added surface strength will provide a longer service life than a normal strength concrete power floated floor.

These products have similar performance properties as dry shake hardeners

but are applied at higher thickness. Dry-shake hardeners are 2-3 mm thick while toppings are applied at 5-10 mm thickness. This added thickness provides additional impact resistance. Toppings are ideal for floors with high traffic and increased abrasion, or/and when extraordinary hardness and toughness is required.



Sikafloor®-3+ CorCrete application in the building materials merchant Dek Znojmo outlet in Czech Republics. Refurbishment of 1200 m² concrete slab with the color Light Grey.



Fast floor refurbishment with SikaScreed® HardTop-70.



Application of Sikfloor®-30 Level overlay in a parking deck.

The aggregate blend may vary among different toppings, similar to dry-shake hardeners, providing different performance properties. A topping may be applied using a “wet-to-wet” or “wet-to-dry” method.

“Wet-to-wet” application refers to application to fresh (green) concrete. The concrete substrate is ready for application when the concrete has set to a point where a slight imprint (~3 mm) can be made in the concrete slab. The topping will be spread onto the fresh wet concrete substrate in the thickness of minimal 5 mm. The topping is then power floated with standard concrete finishing tools to produce a smooth and even surface.

“Wet-to-dry” application refers to application when the topping is applied on matured or existing concrete slabs. In this case, a bonding bridge between the matured concrete and the topping is needed. The wet-to-dry topping is applied at normally 5 mm minimal and is power floated with light weight machines to a smooth and even surface.

CEMENTITIOUS FLOOR SCREEDS

There are two types of cementitious floor screeds: bonded or unbonded. A “bonded screed” is bonded to the slab or substrate below while an “unbonded screed” is separated from the slab and frequently called a “floating screed” when it is installed on insulation. Bonded screeds are normally applied at less than 50 mm thickness. Unbonded screeds are typically applied thicker at 70 mm or more. There are, however, some high strength polymer modified screeds which may be applied thinner. The thickness depends on loads, shrinkage behavior of the

material, screed flexural tensile strength and, in case of a floating screed, the stiffness of the insulation layer.

Floor screeds may fail when incorrectly applied. Bonded screeds fail when the bond between the screed and the substrate fails. This is more likely to happen if the screed is too thick. Unbonded (floating) screeds may fail if applied too thin resulting in lifting or curling.

Floor screeds can be either a traditional cement sand screed or more recently developed proprietary pumpable polymer-modified self-smoothing screeds. Cement sand screeds are suitable for all applications, but they typically have long drying time and they are often produced -site, which requires raw material assessment and constant quality control.

The polymer-modified pumpable screeds are ready to use materials, easily applied, and rapidly harden to high strength. Depending on the grade and screed consistency they can be applied at different thicknesses as bonded or unbonded screeds. The polymer-modified pumpable screeds save installation time and produce a highly abrasion resistant finish. They can also be coated within few hours with resinous high-performance coatings.

SikaScreed® Hardtop

SikaScreed® HardTop is a family of fast curing, rapid load bearing and over-coatable levelling screeds. HardTop screeds can be over-coated after 4 hours with Sikafloor®-161 epoxy primer and they reach compressive strength 35 MPa after 24 hours (at +20 C).

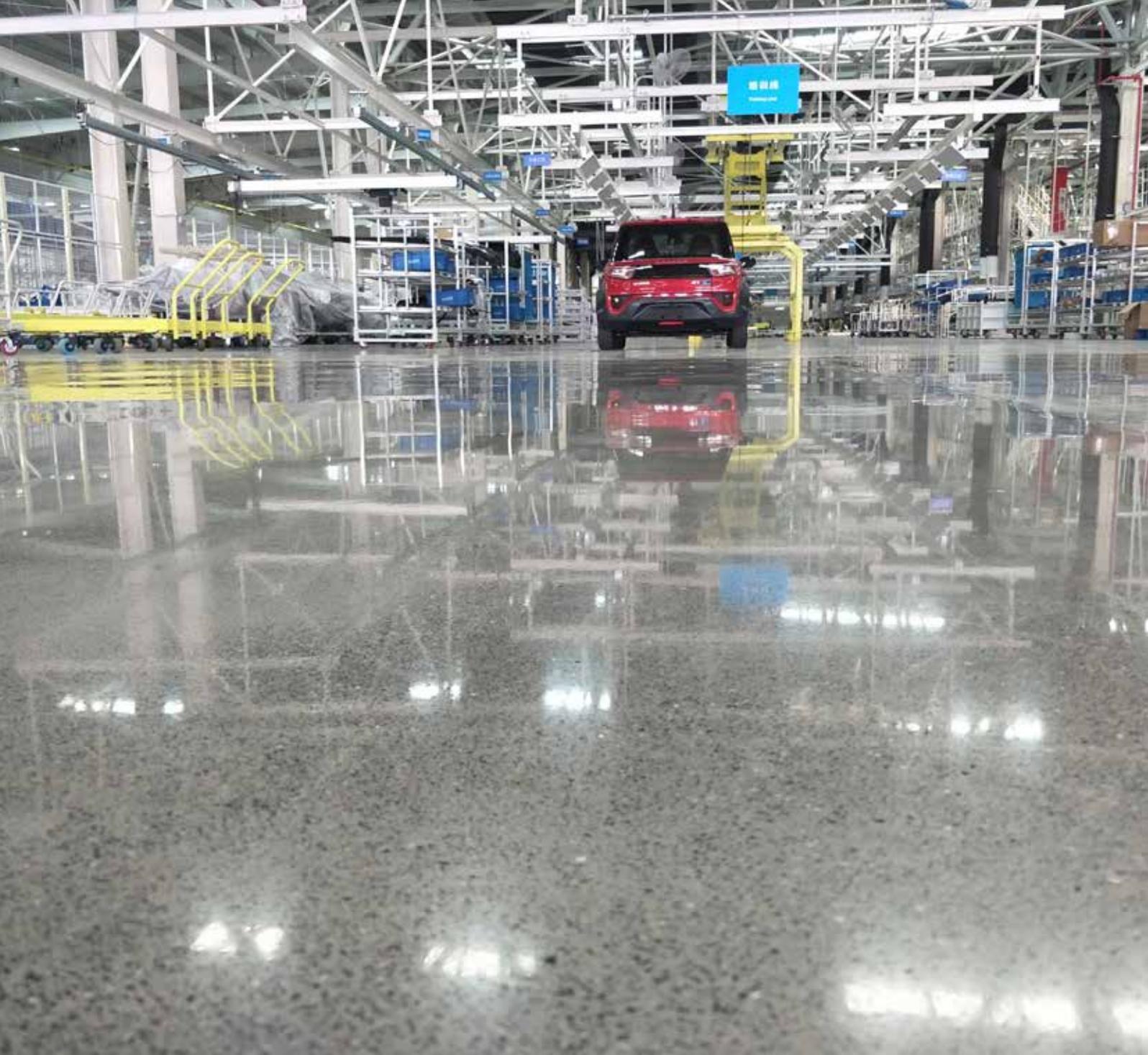
CEMENTITIOUS SELF-LEVELLING OVERLAYS

Cementitious self-levelling overlays, as the name reveals, are materials with low viscosity and high flow. They typically applied at 5 mm thickness and have a smooth finish that can be used as a final surface in medium service conditions. These systems have rather good wear resistance but are not recommended in areas with extreme heavy-duty service with impacts and hard wheeled traffic. The main application of self-levelling overlays is for light commercial and industrial use with pedestrian and fork-lift traffic with pneumatic tires.

Self-levelling overlays can be applied by hand or by pumping, reaching high daily yield. It is recommended that the overlay be treated with a suitable sealer or penetration hardener to densify the surface, minimize dusting, and reduce staining. Some overlays are also suitable for coloring and polishing.

SUMMARY

New or existing concrete slabs can be enhanced using a variety of cementitious surface treatments. Each of these provides improved performance, service life and aesthetics. Selection of the best finish is driven by the service conditions performance requirements, the existing conditions, and the schedule requirements.



POLISHED AND COLORED CONCRETE FLOORS

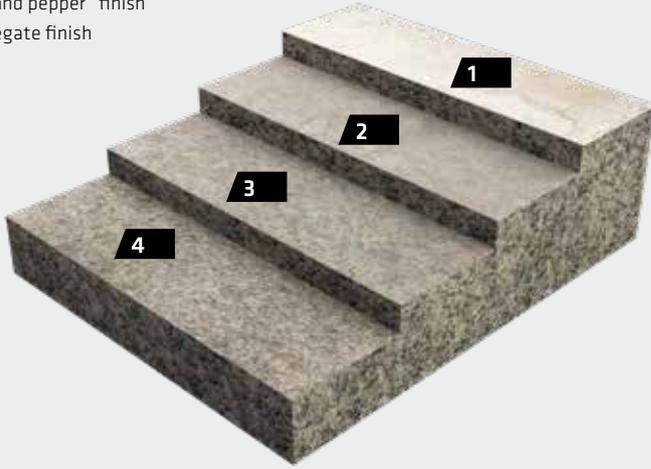
In a variety of applications, the concrete floor can be finished by polishing and coloring to contribute to the facility design. This article will discuss the techniques used to polish and incorporate color into the concrete to produce “architectural concrete”.

ARCHITECTURAL CONCRETE

Architectural concrete is any concrete that is a visible part of the intended design delivering aesthetic appeal. It is any hardscape, precast or cast-in-place concrete that is designed and installed to add a certain look or feel to a project. Not just utilized for its typical strength and structural characteristics. The rich patina and natural texture of colored concrete

THE THREE GRINDING GRADES DEFINE THE DEPTH OF THE GRINDING

- 1 Non grinded surface
- 2 Light and creamy finish
- 3 "Salt and pepper" finish
- 4 Aggregate finish



Aggregate finish grinding with Class 4 polish level.
Source: HTC Professional Floor Systems.

are design elements for both interior and exterior floors. Contrasting shades of concrete can introduce variety within large expanses of open space such as business and retail centers, and subtle harmonizing colors can be used to blend pathways, planters, curbs, walkways and other details within a surrounding landscape.

Architectural concrete is long-lasting. It has excellent thermal properties helping to moderate temperatures in interior spaces. It can be a cost-effective solution compared to many other floor finishes. Concrete colorants are available in a wider array of colors than brick or pavers. Color options range from industrial gray or natural earth stones, to reds, blues and greens. Utilizing the natural properties of concrete allows for versatile application of complex shapes, curves and vertical installations.

WHAT IS A POLISHED CONCRETE FLOOR?

Ground and polished concrete is a mechanical process by which cured concrete is honed using a series of grinding steps utilizing progressively finer diamond grinding tools to achieve the desired level of smoothness, aggregate exposure, and gloss. This process also includes the use of concrete densifier/hardener which penetrate the concrete and creates a chemical reaction to help harden and dust proof the surface.

Diamond polishing as a finish is a relatively recent concept for the construction industry. Earlier diamond grinding equipment was primarily used as a surface preparation tool for concrete floors prior to the application of resin floorings.

The recent advances in polishing equipment and techniques which can grind the surface to high gloss with a chemical hardener creating a highly finished appearance have made the concept more popular.

The final polish has a natural stone appearance and can create the look of granite or terrazzo. The highly polished surface can provide excellent light reflectivity properties. A polished architectural concrete floor is relatively easy to maintain. The polished concrete can also be colored using techniques discussed below to achieve a highly decorative finish. Polishing is suitable for refurbishing old concrete flooring or finishing new installations with increased durability, low maintenance, and high-gloss.

SURFACES OPTIONS

There are many options available for different polished concrete designs. Different levels of aggregate exposure, degrees of reflection, and coloring options will change the visual aspects and physical characteristics of the polished concrete floor. Combining these three variables provides the designer with a variety of aesthetic options.

Aggregate exposure

The aggregate exposure of the floor, similar to terrazzo finishing, represents the amount of ground aggregate exposed at the surface.

The four grades of grinding are:

- Light sand or cream finish. Grinding exposes only the sand particles in the concrete and has a "creamy looking" surface.

- Salt and pepper finish. This finish is often chosen to give the appearance of an aged surface exposing a spattering of fine aggregate. The approximate surface cut into the concrete is about 1.5 mm.
- Aggregate finish. An aggregate finish exposes the greatest amount of medium aggregate and the larger aggregate is exposed to the extent of continued grinding. The surface cut depth varies typically from 3 to 6 mm.

Gloss level

Polishing the concrete will create a level of gloss which is classified by Class. The higher the grit used in the polishing process, the higher the level of light reflectivity of shine. Most frequently, the concrete is polished using a stepped process of progressively higher grit sizes.

Four degrees of shine classes are defined:

- Flat and ground polish can be obtained by using 100 grit polishing pads. The floor appears hazy with little or any reflection
- A Class 2 honed polish is obtained by stopping the treatment at the 400 grit. It produces a low-sheen, satin finish.
- A Class 3 polish is achieved by going up to 800 grit or higher. The surface will have much higher sheen than of Class 2 and it will start to show good light reflectivity.
- A Class 4 polish produces a high degree of shine and has total reflection clarity. A Class 4 is obtained by treatment from 1500 grit and above, or by burnishing the floor with high-speed burnisher using specialty buffing pads.

The gloss level can be determined by using a gloss meter device, which express the degree of light reflection.

COLORING

While gray concrete is the norm, color can add significant dimensions to polished floor. With new installations, integral color can be added to the fresh concrete mix, or for a more intense effect, installed by the concrete contractor as a dry shake hardener. Color can also be applied to hardened concrete in the form of a reactive stain or penetrating dye after the polishing process. The color options range from industrial gray to reds, blues, and greens.

The most common ways to color horizontal concrete are:

- Integral coloring
- Colored dry-shake hardeners
- Reactive and waterbased stains
- Concrete dye

Integral coloring

Integral colorant is a powder or liquid added to the concrete at the ready-mix plant or in the mixing truck. The concrete is colored throughout the concrete slab. Generally used with a gray portland cement mix design, the products result in subtly muted earth tones. The integrally colored concrete can be placed full-depth or as 50 mm topping over the structural slab.

With certain treatments, one integral color can resemble several different colors. The appearance of integral colored concrete can be altered by mechanical means or the use of surface retarders. It is important to use the recommended curing and sealing materials to ensure the compatibility with the colorant.

Dry-shake color hardener

Another method commonly used to color architectural concrete is the use of color hardener.

A dry-shake color hardener is a blend of silica aggregates, cements and iron oxide pigments, and is applied by broadcasting the dry blend onto the concrete surface during placement. Color hardeners offer a larger range of colors than integral colorants because the color is not affected by the base color of the concrete. Dry shake color hardeners enhance the concrete surface durability because of the added silica aggregates and cement applied to the surface. The main limitation of using color hardener is the cut level or “grade” of a polishing process is limited to Class 2. Any further grinding would begin to remove the color hardener from the surface.

A successful installation requires uniform, consistent application and utilizing the recommended ‘cure and seal’ materials. Project coordination and expectations are best managed by organizing a pre-placement conference and installing a mock-up.



Integral colored pavement with Sika® concrete colorant.



Sikafloor® colored dry shake hardener in a restaurant.

Reactive (acids) stains

Acid-based stains may be used on existing concrete. New concrete must be cured (hardened) for a minimum of 30 days and best results are achieved if the concrete is at least 60 days old. This coloring technique only colors the surface of the concrete and is dependent upon the surface porosity. For this reason, acid stained concrete is applied to unpolished concrete or after the concrete has been polished, but not sealed. The stained concrete can be sealed to produce a glossy finish.

Acid stains are a blend of water, acid-soluble metallic salts and hydrochloric acid. The blend reacts with the concrete to produce a permanent distinctive pattern. The color will not be uniform and is dependent upon the concrete composition variation.

Reactive stains are a popular choice for architects due to its durability and lower relative cost. The acid stain produces a unique variegated, time-worn patina most typically in earth tone colors – browns, greens and blacks. This coloring technique can be applied to interior flat-trowelled floors or exterior concrete. Because acid stains chemically bond to the concrete it is prudent to test the stain on the concrete to visualize the finished product prior to application.

Water based stains

Water-based stains are applied to existing or fully cured concrete surfaces. The colorant is limited to the surface of the concrete and sealers are used to protect and maintain the floor. Water-based stains are self-priming, low odor reactive polymers for use on interior or exterior concrete floors. The application process is relatively quick, and the color density can vary based upon application technique. Infinite artistic effects can be created by spraying, layering, spattering or sponging multiple colors on top of each other. A wide range of designer colors are available and water-based stains are ideal for blending patches into older colored floors.



With Butterfield Color® reactive acid stains colored external concrete slab.



Private house concrete floor finished with Butterfield Color® water-based stains technology.

Concrete dye

The concrete dye is the primary coloring choice for ground and polished floors. They can be used to alter existing gray or colored concrete. However, they are not UV stable and should be only used on interior floors.

The concrete dye is liquid applied (sprayed) to the concrete during the grinding and polishing process. Usually the dyes are applied at the grit level just prior to the final polishing step. The concrete is colored at the surface producing a rich, jewel-like appearance and can produce vivid red, yellow, blue and green colors. Single or multiple applications are possible. Multiple applications produce richer colors.

LIQUID HARDENERS AND DENSIFIERS

Densifiers are typically silicate products. Silicates react chemically with the calcium hydroxide produced during concrete hydration to form a new crystalline structure within the concrete pores. Silicates react with the calcium hydroxide to produce new CSH gel, or calcium silicate hydrate. The production of additional CSH within the concrete slab densifies the surface helping to seal and dustproof the concrete. When used during the grinding and polishing process, silicates aid in the burnishing process to produce and maintain some higher levels of gloss.

Due to the nature of the different coloring techniques, the application order of the densifier and colorant and coordination of the grinding steps is important. For uncolored and integral colorant, the densifier is applied at the 150 grit stage.

Once the floor is densified the polishing process is faster and reduces the wear of the diamond pads. An acid stain is applied and densify at the 200-400 grit stage. A densifier is then re-applied to repair the surface from acid stain reaction. A liquid dye is applied at the 400 grit stage followed by densification to lock in the color.

SPECIFICATION CONSIDERATIONS

Hardened concrete properties greatly affect the quality of the polishing project. A high sheen finish requires high strength concrete. For new concrete installations, specific mix design requirements help prepare the material and reduce extra costs in surface preparations. Normal weight, non-air-entrained concrete is required, with a minimum compressive strength of 24 MPa (3500 psi). Natural concrete slump admixtures may be used. The surface finish should be tight hard-troweled, with no burnish marks. The floor should be finished as flat as possible. The larger the variance in floor tolerances, the more grinding required to reach a uniform aggregate exposure. Membrane-forming curing compounds are not recommended especially when colorants will be used, but sheet curing membranes or wet curing for 7 days will enhance the concrete performance properties.

MAINTENANCE

Maintenance of polished concrete is just as important as it is for any surface receiving wear. Polished floors are porous and prone to staining when subjected to reactive and penetrating spills, such as acidic materials and oils.

Clear maintenance guidelines should be established during the planning stages and passed on to the owners group for their maintenance program. Routine maintenance should consist of daily dust mopping and frequent clean water mopping. When chemical cleaning is required it is advised to use a neutral pH cleaner. Floor wax are never needed on a polished concrete floor.

Typically, mechanical cleaning is recommended using diamond impregnated pads on a buffing machine. The grit of the pad used is directly related to the gloss or class established for the floor. For example, if the floor was polished to an 800 or Class 2 gloss, then the same or higher grit pad should be used for maintenance, using a lower grit pad will dull a high grit finish.

SUMMARY

Concrete floors can be finished to various gloss levels, colors and patterns to achieve the design goals of the facility. Several levels of polishing and aggregate exposure offer options with respect to overall aesthetics. Both existing and new concrete can be colored to produce a variety of finished appearances in combination with polishing. These floor finishes are relatively easy to maintain and will provide years of service.

POLISHING AND COLORING PROCESS

Below is an overview of a typical ground and polished process. This will vary from project to project depending on the condition of the floor, the coloring system used and the specification for the finished appearance. Typically, the floor only needs to be densified one time, when you densify will depend on the coloring system used on the floor.

1. Treat joints / joint filler / any grinding required
2. Initial grind / metal diamonds: grid 16-25-50-100-250
3. Densify - uncolored concrete, integral colored, acid stain
4. Resin diamonds / honing: grid 100-200-400
5. Liquid Dye or Acid Stain application / 400 grit
6. Neutralize floor when Acid Stain is used
7. Lithium Densifier application: (Allow floor to dry completely)
8. Resin diamonds / grid 400-800-1500-3000
9. Application of a guard / protection
10. Burnish the surface



Operator changing metal bond diamond tools under an HTC DURATIQ grinding machine. The green Superprep tooling series is specifically developed for heavy preparation works.



HTC 950 RX radio controlled floor grinding machine producing HTC Superfloor™, a mechanically refined concrete surface providing high wear resistance, aesthetics and minimized dust.



SIKA CONCRETE FLOORING SOLUTIONS

CAR ENGINE PRODUCTION FACILITY, UK

PROJECT REQUIREMENT

The design and construction of this 30,000 m² car engine production facility required a flooring surface that would withstand aggressive service conditions and provide an easily maintained, safe and attractive finish. The designers selected a highly durable integral colored floor hardener rather than a surface applied resinous material. In these service conditions, the integral finish is extremely durable minimizing maintenance and eliminates recoating or replacement due to wear of surface applied resinous systems. In addition to optimal performance, the client wanted the most sustainable concrete mix achievable to help attain the required BREEM (Building Research Establishment Environmental Assessment Method) Rating.

SIKA'S SUSTAINABLE APPROACH

Sika's Global Product Sustainability Group performed a Life Cycle Assessment (LCA) of various solutions to help the customer choose the optimal solution. Sika recommended a full system approach including the impact of the concrete slab itself and the subsequently applied flooring system.

Two floor systems with similar performance properties were assessed through LCA in order to show the benefits of using a High Range Water Reducer (HRWR). A

traditional flooring system was compared to system whose concrete mix contains the HRWR Sikament® 700. Both flooring systems included a concrete layer and a dry shake flooring hardener Sikafloor®-2 SynTop designed specifically for the project. The HRWR Sikament®-700 solution had Global Warming Potential (GWP) and Cumulative Energy (CED) categories showing 6% and 5% lower impact than the traditional approach. The client was highly satisfied with the finished project and the support and knowhow of Sika UK in the innovative and sustainable approach in selecting the best system.

TECHNICAL SOLUTION

Concrete production: Sikament®-700 High Range Water Reducer
 Flooring: Colored Sikafloor®-2 SynTop surface hardener and curing agent
 Sikafloor® Proseal





JINGDONG “ASIA NUMBER ONE” LOGISTICS PARK, CHINA

PROJECT REQUIREMENT

The state-of-the-art warehouse and distribution center located in Shandong Qingdao, China required super flat flooring to support the use of automated robotic forklifts and product pickers. The floor flatness tolerance was specified to be within 3 mm variation over 2 meters. High speed automated equipment operating in high racking distribution centers mandates precision flatness and levelness to prevent accidents, equipment and product damage. The narrow aisles and programmed traffic require the work surface to have high wear and good impact resistance.

SIKA'S RECOMMENDED APPROACH

Sika provided a complete flooring design solution. The control and construction joints were designed to avoid traffic patterns. The concrete flatness and levelness was detailed to meet the various areas of operation. The concrete floor was finished with wear resistant mineral Sikafloor®-3 QuarztTop floor hardener with Sikafloor® CureHard-24 liquid hardener. The joints were sealed with Sikaflex®-11 FC.

CLIENT REACTION

Due to the high level of technical support, installation guidance and product performance, Sika has been awarded Jingdong's sole brand strategic partner for warehouse floor construction throughout China. "Sika provides a one-stop service, from foundation concrete to surface concrete works and follow-up maintenance. Sika has been the first to initiate "concrete for

flooring" and supply it in a real sense as a fully integrated flooring solution. Sika provides a full-range of supporting materials including concrete admixtures for flooring, steel fibre, prefabricated free movement joints, dry shake wear-proof flooring, liquid sealant hardener, a line of epoxy and polyurethane flooring, and joint sealing materials."





HIXIH RUBBER INDUSTRY GROUP, TYRE AUTOMOTIVE ASSEMBLY HALL, CHINA

PROJECT REQUIREMENT

Hixih Rubber Industry Group expanded into the tire manufacturing business through its joint venture with Pirelli & C SPA in 2005. Shenzhou Tyre and Tongli Tire Co Ltd subsidiaries in Jining, Shandong are undergoing a 450,000 m² (\$410 million) physical expansion to be completed from 2018 to 2021. The immediate project of 200,000 m² project specified a flooring system capable of supporting the aggressive manufacturing environment as well as the warehousing function. Floor flatness was specified for a maximum 5 mm variance within two meters.

SIKA'S RECOMMENDED APPROACH

Sika provided a complete system solution recommendation based upon extensive experience in these environments throughout the world. Newly installed concrete was finished with Sikafloor®-2 SynTop 2 dry shake hardener with joint profile Sikafloor®-2 Seam AM. The client is satisfied with the installation and has established a 10 year trust and co-operation agreement with Sika service.

TECHNICAL SOLUTION

Flooring: Sikafloor®-2 SynTop 2
Joints: Sikafloor®-2 Seam AM





FLOOR REFURBISHMENT, BOREALIS CHEMICAL PLANT BELGIUM

PROJECT REQUIREMENT

Borealis operates in over 120 countries and has production facilities throughout Europe and the United States. Borealis is a leading provider of innovative solutions in the fields of polyolefins based chemicals and fertilizers. At the Kallo, Belgium site, not only is the company designing a new world-scale propane dehydrogenation (PDH) plant to be placed in service in 2021, they are maintaining existing facilities for safe and efficient operations. The current project was 2,800 m² flooring renovation. In the production hall the concrete floor had unacceptable tolerances (+3 mm/-37 mm) varying from area to area. The required flatness tolerance was 2 m +/- 3 mm. The operating conditions required the flooring system to withstand heavy forklift traffic, be resistant to impacts, and have good chemical resistance. The floor joints were required to accommodate movement while providing a level transition for heavy traffic. The working time was short to minimize disruption of the operating facility.

SIKA'S RECOMMENDED APPROACH

Sika representatives conducted a site evaluation and suggested a complete system solution to meet the performance requirements of the operation and meet the renovation schedule. For fast repair and leveling, SikaScreed® HardTop-60 with bonding agent SikaScreed®-20 BB

was specified. The primer Sikafloor®-161 functioned as a curing agent for the screed. This system was coated with Sikafloor® MultiDur EB-24. Sikafloor® FloorJoint S joint panels (52 meters) were installed in heavily trafficked joints.

TECHNICAL SOLUTION

Flooring: SikaScreed® HardTop-60 with SikaScreed®-20 BB
Coating: Sikafloor®-161 primer and Sikafloor® MultiDur EB-24 coating
Joints: Sikafloor® FloorJoint S joint panels





CATERPILLAR SERVICE FACILITY, ORDAN

PROJECT REQUIREMENT

The Jordan Tractor & Equipment Co is the sole dealer in Jordan for Caterpillar Inc. The company provides complete support throughout the entire Life Cycle of the equipment, starting from product acquisition (new, used & rental), genuine parts and culminating in professional after-sales support (top-class service, aintenance & support); thereby ensuring minimal breakdown & long life of your equipment. The range of equipment spans from small hand trucks to massive earth moving tracked vehicles. The facility must capable of handling the entire breadth of traffic while maintaining a showroom appearance.

SIKA'S RECOMMENDED APPROACH

The 10,000 m² facility was specified to receive metallic dry shake hardener Sikafloor®-1 MetalTop with liquid hardener Sikafloor® CureHard-24. This "hard-top" finish provides a long lasting durable floor for the most aggressive abrasion and wear conditions. Joints were sealed with Sikaflex® Pro 3.

TECHNICAL SOLUTION

Flooring: Sikafloor®-1 MetalTop with liquid hardener Sikafloor® CureHard-24
 Joints: Sikaflex® Pro 3





COLLEGE OF DUPAGE HEALTH & SCIENCE CENTER, GLEN ELLYN, IL, USA

PROJECT REQUIREMENT

The College of DuPage located in Glen Ellyn, Illinois (USA) constructed a 186,000 ft² (17,280 m²) multidiscipline science center to include laboratories, classrooms and simulated hospital environments. Floor finishes needed to handle heavy foot traffic, wheeled traffic, while maintaining a high level of aesthetics, easy maintenance, and good ultraviolet light stability through the building's glass facade. The Health and Science Center was being registered under the LEED Gold Certification program from the U.S. Green Building



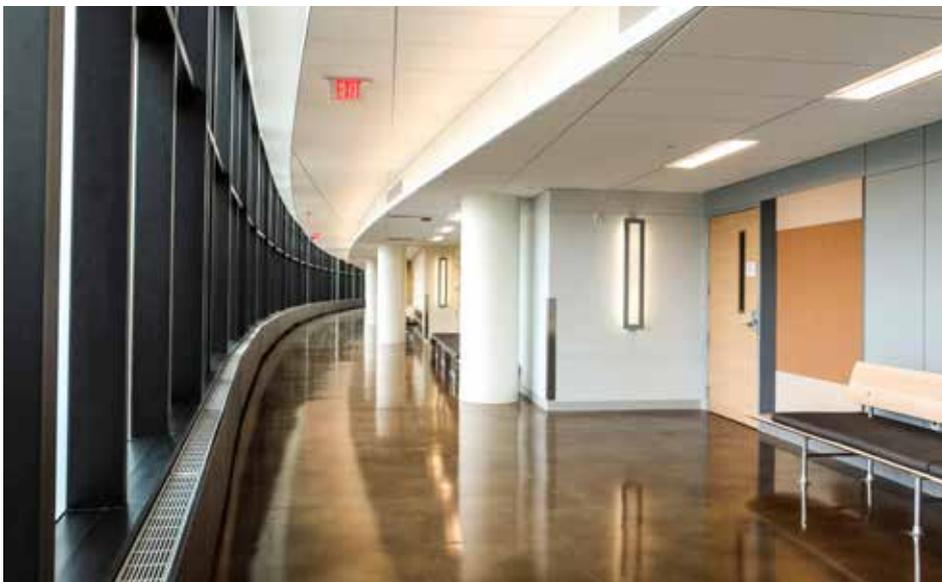
Council and floor finish materials needed to meet VOC limitations. Maintaining the construction budget of \$60 million was also a primary consideration.

SIKA'S RECOMMENDED APPROACH

Sika consultants worked with HOK to select the best products to meet the performance, aesthetics and budget requirements. Hallways and common areas throughout the building exposed to UV light were specified to receive Butterfield Elements® Transparent Concrete Stain. This product is water-based, low VOC (15 - 45 g/L) and contains the latest nanopigment technology to readily permeate into the concrete. The stained concrete was then sealed with Butterfield Color® Clear-Guard™ Cure and Seal. This non-yellowing, VOC-compliant high-gloss sealer increases the strength and durability of the concrete surface while enhancing the appearance and coloration of decorative concrete.

TECHNICAL SOLUTION

Flooring: Elements® Transparent Concrete Stain Clear, Butterfield Color® Clear-Guard™ Cure & Seal.



MAINTENANCE OF DRY-SHAKE AND INDUSTRIAL CONCRETE FLOORS

Concrete floors in industrial environments must be maintained for safety and operational efficiency. Dry-shake hardener floor surfaces improve the concrete durability. But all industrial concrete floors require proper maintenance which is key to securing long-term performance and functionality. The industrial floor is subjected to constant traffic, various chemical exposures due to normal operations, and assorted dirt, debris and particles that contribute to abrasion and wear. Failure to maintain concrete floors and joints will ultimately lead to high long-term costs or repair and replacement as well as, and lower operational efficiency. A philosophy of planned maintenance, cleaning and repair should be adopted as soon as the floor is constructed, preferably in the design phase.

CLEANING PRIOR TO FLOOR USE

Regular cleaning is essential to prevent dirt and dust build up from contributing to increased surface wear. Moisture, chemicals and oils must be cleaned to protect the surface and more importantly maintain a safe traffic pattern. Floor protection begins before the facility is opened to operations. The facility construction operations can expose the floor to more severe abrasion or contamination than anticipated from the planned industrial traffic.

The following guideline provides recommendations for cleaning dry-shake floors at various stages (grade of maturing):

- Newly finished floors – Less than 7 days. Slight mechanical cleaning, washing without using any chemical agents or abrasive tools.
- 7 – 28 days. Mechanical washing with vacuum using softer brushes or non-abrasive floor pad and neutral or slightly alkali chemical cleaners.
- Regular Cleaning – More than 28 days. Mechanical washing with vacuuming using brushes or medium hardness floor pad and neutral or alkali chemical cleaners.

ROUTINE CLEANING CONSIDERATIONS

Dry-shake floors finished with hardeners are sealed and will not generate dust due to traffic. However, the dust from surrounding operations collects on the surface. The floor should be routinely cleaned using a cleaning machines with vacuum and disc or cylindrical brushes equipped with silicon or polypropylene bristles of medium stiffness. Avoid using machines with very hard, e.g. steel, brushes as they can leave circular marks on the topping.

Cleaning agents

Cleaning agents must be free of organic solvents or highly concentrated alkali. Do not clean floors with strong organic solvents (acetone, toluene, xylene, trichloroethylene etc.). Generally, it is not suitable to clean floors with acidic chemicals as hydrochloric, phosphoric or acetic acid, as these can adversely react with the concrete. Each cleaning agent should be evaluated for effectiveness and approved individually before use. After chemical cleaning, the surface should be carefully and thoroughly rinsed with clean water.

Frequency

The frequency of the cleaning depends on the type of contamination, the operations schedule, safety issues, and level of cleanliness desired. For maximum effectiveness, cleaning should be carried out daily or weekly as a part of a minimum standard housekeeping procedure. More frequent cleaning procedures may be necessary due to operational changes or special circumstances. Professional machines and tools are recommended for more efficient reproducible results rather than hand washing or sweeping.

Tire marks

Tire marks can be difficult to clean and may not be completely removed by machine cleaning. Concrete floors have a porous surface. When there are fast moving or turning equipment (forklifts), the rubber from the tires can be driven into the floor surface at the contact points. This kind of contamination cannot be fully removed. The floor surface can be essentially improved by cleaning with alkali washing cleaners and with abrasive hard floor pads; floor can be locally cleaned with some kinds of solvents.

Spillages

Chemical and oil contamination should be cleaned immediately for user safety and for the protection of the floor. The longer the spill resides on the surface, the more the contaminant will penetrate into the floor. This may result in staining, or damage to the concrete floor. The cleaning process must neutralize or degrease the spill and thoroughly rinse the surface with clean water.

MAINTENANCE OF SURFACE DAMAGES

How well the floor surface will wear is dependent upon the type of materials handling equipment (MHE), their loads and tires, cleanliness of the floor and traffic intensity. Most dry shake floors are finished with an acrylic curing agent that will provide additional durability under normal floor use. These agents are designed to gradually wear to reveal the concrete surface but in the case of heavily trafficked floors, they should be reapplied routinely using a roller or spray after the floor intensive cleaning.

Physical damage to the floor surface can occur from impact damage from dropped goods or tools, scuffing of pallets or tines, joint edge erosion from traffic impact, or random cracking. Cementitious screeds or polymer mortars should be used as repair materials. A repaired patch is almost always visible due to the differences in materials and their age. High performance coatings can be used to improve aesthetics. The coating must be selected to meet the operational performance requirements. The concrete surface must be properly prepared to insure a good adhesion

WAYS TO IMPROVE AND REFRESH SURFACE LOOK

Concrete floors with a dry-shake finish have a typical look and color. However, there are many treatments that can be used to enhance the surface appearance of a concrete floor. Many of these will also provide additional protection for the concrete, sealing it against water penetration and forming an easy to clean layer

over the core of the already durable slab structure.

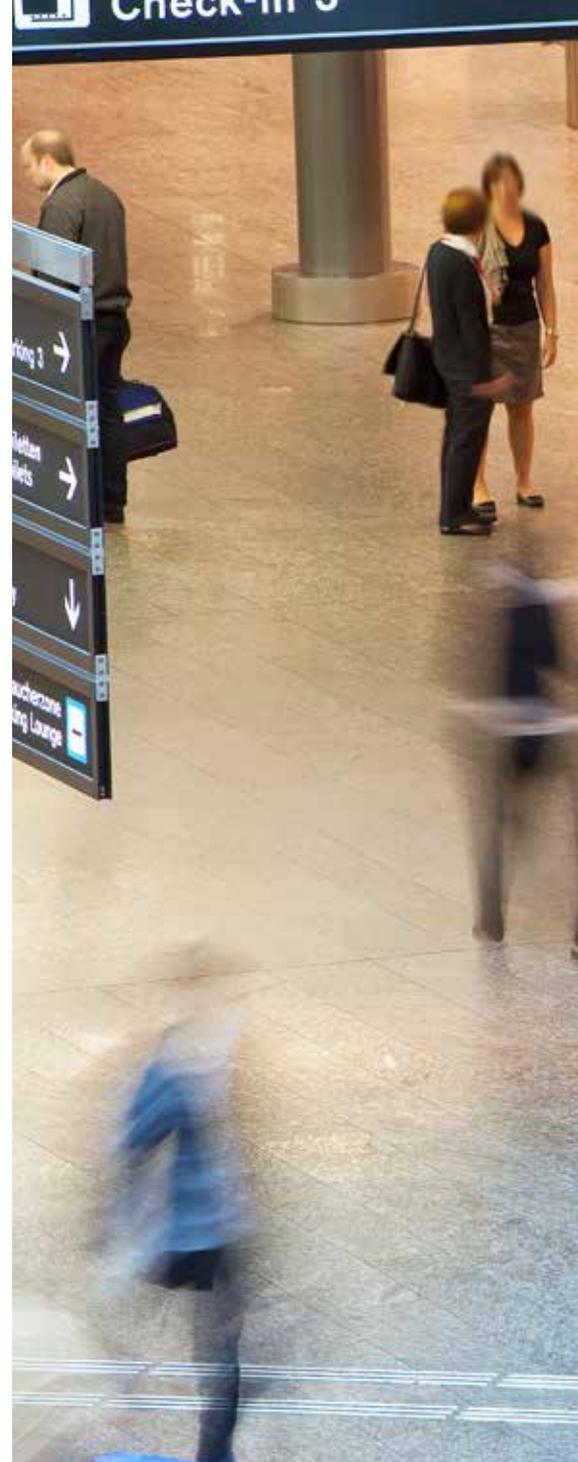
DEEP CLEANING

In addition to routine maintenance procedures, dry-shake floors in industrial buildings, should be deep cleaned at least once a year. Deep cleaning is performed using a disc washing machine with higher pressure than those used during routine maintenance. The correct deep cleaning process it can remove the most resistant marks, such as tire tracks, etc. When using detergents at higher concentrations it is necessary to completely neutralize the floor surface after cleaning by rinsing with clean water.

USING SILICATE SEALERS

Additional application of silicate sealers will prolong the life of the concrete floors. This application is recommended every two years under normal use conditions. Sodium silicate or lithium silicate sealers penetrate the concrete surface and initiate a chemical reaction with free calcium carbonate. The new crystals are formed, fill the pores and increase the concrete tightness. Application of silicate products improves surface look, and improves the abrasion resistance of the concrete surface. The silicate chemical reaction within the concrete continues after the initial application improving the hardness and water-tightness several days after application. The surface gloss gradually increases during 30 to 90 days depending upon cleaning frequency. Regular machine cleaning further improves the gloss and aesthetics of flooring surface.

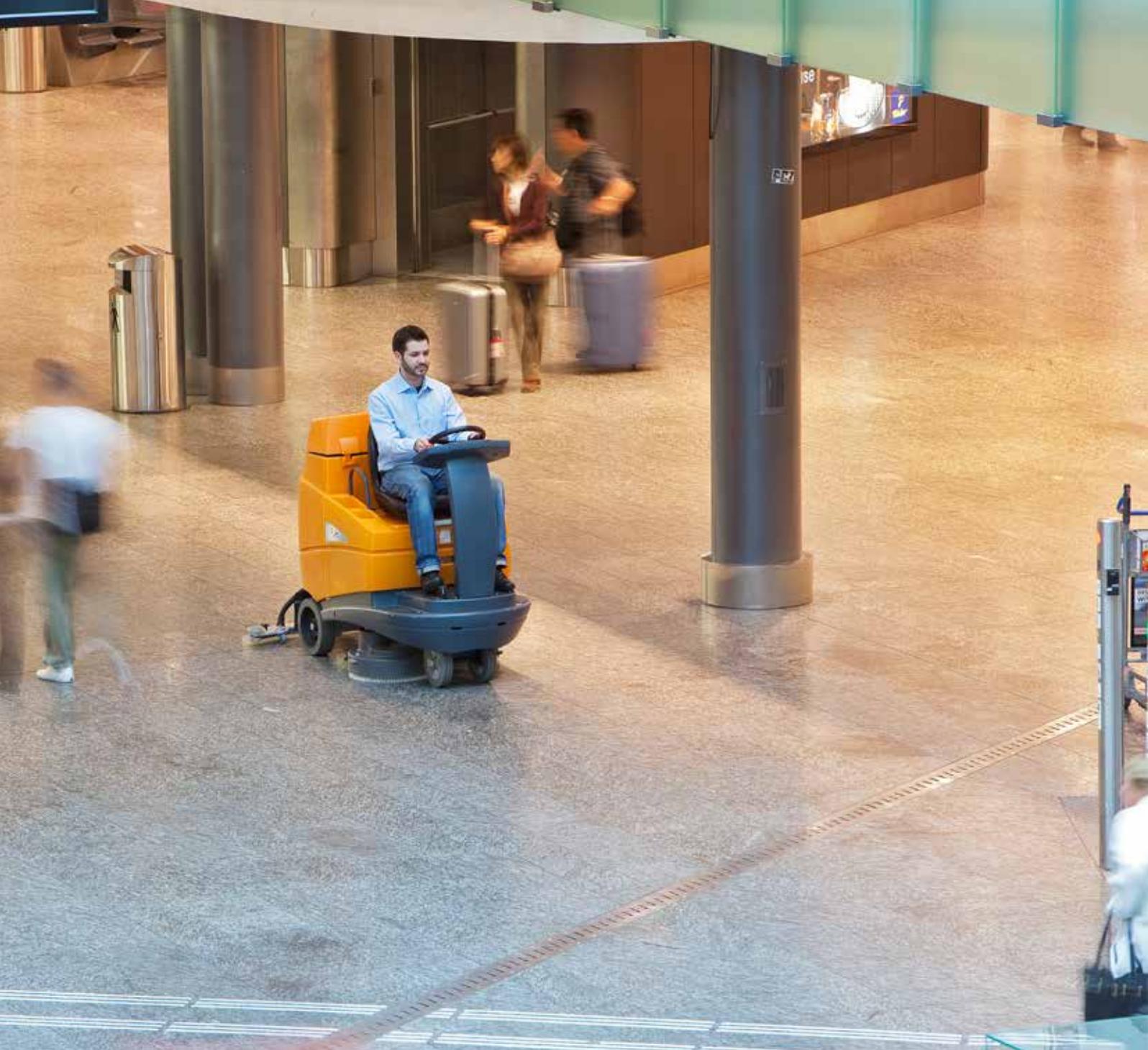
To enhance the gloss appearance, an additional application of a silicate-acrylic resin can be applied. The product is applied using a mechanical or manual pressure sprayer with adjustable nozzle at the specified rate. Immediately after application it is evenly spread with a flat micro-fibre swab. If the second application is desired, can be applied the same manner after the first application is completely dry. Polishing with soft PAD



will improve the gloss. The surface must be absolutely dry before opening to traffic; a minimum of 24 hours surface drying at room temperatures is required.

SURFACE GRINDING AND POLISHING

A polished concrete floor has a glossy, mirror-like finish. The level of gloss can be controlled by using different methods of concrete polishing. Polished concrete is popular to improve the surface look of older concrete floor especially in commercial buildings making them easier to maintain. Heavy-duty polishing machines equipped with progressively finer grits of diamond-impregnated segments or disks (akin to sandpaper) are used to gradually grind down surfaces to the desired degree of shine and smoothness.



For concrete polishing wet or dry method can be used. Although each has its advantages, dry polishing is the method most commonly used in the industry today because it's faster, more convenient, and environmentally friendly. When dry polishing or grinding, HEPA-filtered dust collection systems and personal respiratory protection are used to minimize exposure to respirable crystalline silica dust. Wet polishing uses water to cool the diamond abrasives and eliminate grinding dust.

Many contractors use a combination of both the wet and dry polishing methods. Typically, dry polishing is used for the initial grinding steps, when

more concrete is being removed. As the surface becomes smoother the process is changed from dry to wet polishing.

GENERAL TIPS FOR GOOD PRACTICE

Clean the floor regularly and remove all debris before it causes damages. In heavily trafficked areas more frequent maintenance is needed. All spillages of chemicals, oils and greases must be removed as soon as possible after exposure. Ensure that the cleaning agents are suitable for concrete surfaces and do not exceed the recommended concentrations. Follow the manufacturer's instructions. It is preferred to run a trial before starting the use. Possible damages, especially at joints, should be treated

as soon as they appear to prevent larger problems. Keep in mind that for durability and long-term functionality all floors need maintenance.

MOISTURE AND DRYING OF A CONCRETE SLAB

Every concrete slab has moisture and will always have moisture. Concrete is a porous substrate that allows the movement of moisture dependent upon the temperature and humidity. The moisture in concrete is from both internal and external sources. The internal source is the water mixed with the cement, aggregate and sand to create. The external sources can come from poor drainage below the slab, rainwater or surface exposure, and the humidity in the air. Most of the excess water in the concrete mix, which is not needed in hydration, will bleed from the slab during consolidation and evaporate as the concrete cures. The remaining moisture will reach the equilibrium with the surrounding environment.

In fact, retaining moisture within the concrete during the curing process is necessary to achieve proper hydration and sound concrete. A plain concrete floor with a dry shake or other permeable topping is not as sensitive to concrete moisture, but when the final finish is an impermeable resin coating, a timber finish, or vinyl sheet flooring, movement of moisture from the concrete will create problems.

WHAT ARE THE WATER SOURCES

Concrete starts wet. Water is added to the concrete mix to facilitate hydration of the cement and provide workability to place and finish the concrete. A typical cubic meter of concrete with a cement-water ratio of 0.5 contains about 160 – 170 kg of water. Approximately half of this is used to hydrate the cement, while the other half, comprising approximately 3.2 % of the weight of the concrete, is so called free water or water of convenience. Wet curing is generally regarded as the most efficient method of curing concrete to ensure the hydration process is completed and the slab achieves the design strength. Wet curing can raise the “free water” up to 7% of the weight of the concrete and will extend the time required for drying. When concrete is

required to dry out in the least possible time, curing methods such as curing compounds used to slow the evaporation rate, should be considered. In addition, the slab should be protected from re-wetting exposure from operations and the environment, as well as, wetting of the subgrade. Ideally the concrete should be placed after building has been enclosed.

For slab-on-ground work, vapor retarders or damp-proofing membranes should be installed under the slab to separate the concrete from ground water that might delay or prevent the adequate drying. Vapor retarder membranes should always be specified when the concrete floor is to be finished with moisture sensitive flooring systems.

Exposed concrete continuously “breathes”. Moisture enters and exits the slab depending upon the temperature and humidity. The presence of warm moist air against a cold concrete surface will result in the condensation of moisture at the surface and the moisture will be drawn into the concrete. Moisture may also condense within the concrete material, known as interstitial condensation.

Acid etching, detergent scrubbing, and water washing are sometimes used to clean or prepare the surface of the concrete prior to the application of a flooring system. Such processes add a considerable amount of water to the concrete and the slab must be dried before applying moisture sensitive finishes.

HOW MOISTURE MOVES THROUGH CONCRETE SLAB

The moisture moves through concrete slab as water vapor and as liquid water. Concrete which is not saturated with liquid water will transmit moisture as vapor by diffusion through the capillaries of the cement paste. As the concrete dries, the water vapor is driven by the difference in vapor pressure (affected by both temperature and humidity) towards the surface to establish an equilibrium. For concrete which is saturated with water, the driving force for moisture movement is capillary action and when it is exposed to air, the driving force is evaporation from the surface.

Drying begins after the curing process. Wet burlap, plastic sheets or other coverage is removed and there is no longer water available at the exposed



Wet curing of the concrete slab is a very effective method of curing. The slab is flooded and ponded with water and kept wet. On the other hand side wet curing raises the “free water” in concrete and extends the drying time.

surface. The relative humidity within the slab immediately after curing is 100% as all pores are saturated.

Three distinct stages can be found in concrete curing and drying process. In the first stage the liquid, bleed water, which is present on the surface evaporates into the air above the concrete. During this stage the concrete will shrink and lose volume. If the evaporation rate is high, the concrete will shrink excessively before the cement paste has developed sufficient strength and cause early phase “plastic shrinkage”.

In the second stage of drying (after wet curing), the surface can no longer shrink due to liquid water evaporation and the water recedes from the exposed surface into the pores. The water from each pore evaporates into the air over the concrete. In this stage the concrete may appear to be dry but is only beginning to dry at the surface. In first two drying stages the rate of evaporation depends on the temperature, humidity, and air flow over the surface.

The third stage of drying begins when enough water has evaporated from just below the surface and the pores are not

continuously filled with water. Liquid water will still exist in the pores, but now moisture must move by vapor diffusion through the slab to surface where it can evaporate. The length of time required for drying in the third stage is determined by the quality of the concrete. In concrete with a high water-to-cement ratio (>0.40) and a high cement-paste-to-aggregate ratio (>0.33), more water is

retained. These conditions produce highly porous concrete and water (as a liquid and vapor) will freely move through the concrete.

When drying occurs a drying profile will be established which displays the moisture content in different parts of the slab cross-section (Figure 1).

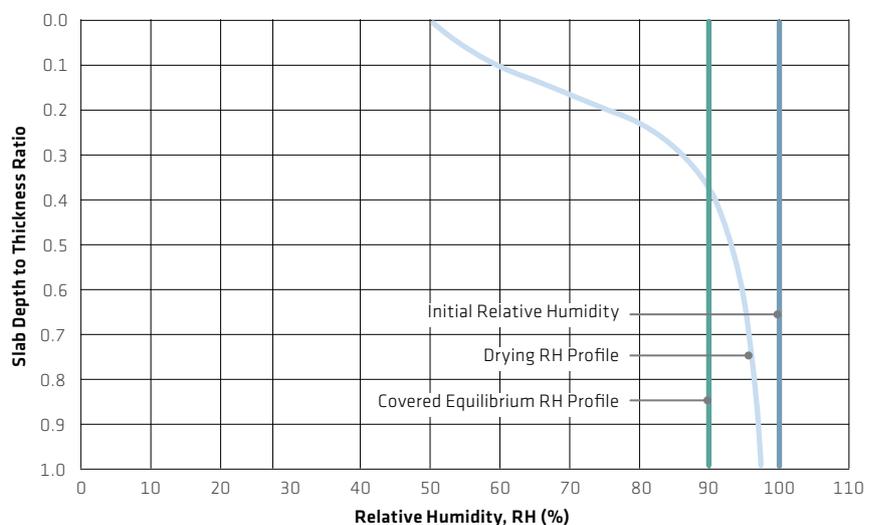


Figure 1: One-sided drying profiles in a slab-on-ground showing the initial drying and covered equilibrium relative humidity profiles.

HOW TO REDUCE DRYING TIME OF CONCRETE SLAB AND LIMIT THE RISK

Using concrete mixture with low water-cement ratio and bleed characteristics, reduces the amount of residual water in the concrete. This leads to a shorter drying period and results in a lower concrete permeability to vapor transmission. Higher strength concrete that is adequately placed, compacted and cured, generally strengths over 40 MPa, will be sufficiently impermeable to reduce the vapor transmission rate through the concrete and hence the vapor emission rate from the surface to an acceptable level. Also concrete with low permeability provides less catalyst for future osmotic blistering.

Concrete with a high water-to-cement ratio produces more capillaries, making it easier for moisture to move through the slab quickly, but more water must leave, extending the drying time. The use of water reducing admixtures assists in reducing the water-to-cement ratio and maintaining the workability required. Concrete scientists suggest that the water-cement ration between 0.4 and 0.5 would be optimal.

Using concrete mixture with low water-to-cement ratio (<0.40) and a low cement-paste-to-aggregate ratio (<0.33) reduces the amount of residual water in the concrete. This leads to a shorter drying period and results in a lower concrete permeability or moisture vapor transmission. Higher strength concrete (40 MPa) with low water-to-cement ratio, low cement-paste-to-aggregate ratio, adequately placed, compacted and cured, will produce a low porosity slab with low moisture vapor transmission rate. Minimizing the amount of moisture exiting the slab is critical to the successful performance of moisture sensitive finishes.

The speed of the evaporation reflects the conditions at the surface of the concrete. However, a thicker concrete slab will take longer to reach equilibrium moisture

content than thinner slabs. According to studies the drying time is doubled when the slab thickness increases from 100 to 150 mm and tripled when increased from 100 to 200 mm.

Wet curing is an excellent method to achieve hardened concrete properties. The industry norm for curing is minimum 7 days. The application of liquid membrane curing compounds are beneficial in providing extended curing times and reducing concrete permeability. On the other hand, they delay the commencement of drying and must be removed for most subsequent concrete finish applications. Therefore, when moisture sensitive finishes or coatings are to be applied, wet burlap or plastic sheeting is the preferred curing method.

Limit additional water sources and re-wetting the concrete especially in older concrete slabs. If any repairs or patching are needed, they should be done as early as possible to allow the repair material to dry. Installing a vapor retarder membrane under new concrete prevents moisture and humidity from entering the slab from the ground.

The drying environment impacts drying times. In low relative humidity or in high temperature environments concrete dries faster. To speed up the drying process (after cure), the space can be heated or hot air blowers can enhance the evaporation rate. However, drying the surface too rapidly at an early concrete age increases the risk of shrinkage cracking and curling. Water evaporation needs time, allowing sufficient time for the moisture in the slab to dry naturally is the best way to avoid problems. Prior to application of any moisture sensitive material the moisture condition of the substrate must be measured and meet the acceptable level for the final finishing system. Surface heating and dehumidification may give misleading moisture vapor emission rates and falsely indicate that the surface is sufficiently dry.



HOW DRY IS DRY ENOUGH?

Three figures appear regularly in literature and guides addressing acceptable concrete moisture for moisture sensitive flooring over a new concrete slab – moisture content in percent, rate of evaporation from the slab and relative humidity within the slab. Measuring moisture content at the surface will generally not give an accurate indication of the final moisture content and if the concrete is dry enough for the application of a floor finish. It is the movement of moisture that is the most critical factor in preventing moisture related problems. Therefore, it is not only important to control the amount of moisture present, it is equally important to control the environment that creates the movement of moisture.

The commonly mentioned “wisdom” is that it takes concrete to dry 30 days per inch of a slab depth. However, as earlier discussed several factors affect how the concrete slab dries, and this rule of thumb is never enough to give a solid basis for making the decision when the floor finish can be installed.

Some product manufacturers use a target value of 5.5% moisture content as measured with surface probes to



Prior to application of moisture sensitive floor finishes it is important to measure and understand the moisture condition in the substrate. Sika has experience and technical knowledge to help and provide sustainable solutions.

specify when concrete is dry enough for their product. However, the concrete with 5.5% moisture content is in equilibrium when relative humidity of the ambient air is 90%. If, however, the ambient relative humidity is only 60%, the equilibrium content of concrete will be 3.9%. In other words, at lower humidity, concrete with 5.5% moisture content is still very wet. Typical recommendations from manufacturers for resin coatings is 4% moisture content, which corresponds concrete relative humidity 93% and ambient relative humidity 65%.

All finishing systems do not have the same requirement and are not equally sensitive to moisture. Most resin coatings, if applied to a well-prepared and dry concrete surface, with a climate-controlled environment, and allowed to cure adequately will develop sufficient bond strength to resist water pressure from both moisture vapor and capillary sources.

All three methods of determining moisture in concrete are valuable. Moisture meters (%) are relatively easy and quick

methods of determining if further testing is required. Humidity test measure the amount of moisture within the slab but not whether it is moving. Emissions tests (calcium chloride) provide a rate of moisture leaving the slab. None of these methods are directly correlated and they all will vary with changes in the environment. Every flooring installation is different and the participants of the project must know the acceptable conditions and limitations of the specific flooring finish. The manufacturers of each flooring product have developed recommendations for their specific products.

SIKA SOLUTIONS

Time is money and today construction schedules are extremely tight. Concrete substrate needs to be given time to dry. For projects requiring the installation of moisture sensitive finishes, it is essential that adequate drying time is allowed. Most failures within surface finishing and floor coating works on concrete structures originate from too high moisture content of the base slab. The successful application of such materials requires an

understanding of the sources and movement of the moisture in concrete, and proper concrete design, placement and curing.

Sika has extensive experience in dealing with coatings and flooring systems. As a global market leader of industrial flooring, Sika has also developed solutions to overcome the issues with moisture. Sikafloor® Epocem technology is a proven system making Sika a leader in the market. Other Sika provided solutions include water vapor permeable (“breathing”) resin systems and special moisture mitigation primers. Every case on a construction site is different and Sika’s technical personnel around the world are happy to assist.

Sikafloor® SOLUTIONS – A SAFE AND DURABLE MATCH FOR YOUR SPECIFIC NEEDS



What makes a floor a Sikafloor®? At Sika, the global leader in innovative flooring solutions, we listen carefully to what our customers want and need, stay abreast of changes that can impact your business, and make significant investments in research, development and testing in order to bring you trusted, engineered solutions based on evidence and best practices. Our time-tested, proven approach is rooted in more than 100 years of experience developing technologies used in flooring as well as concrete production, below-ground waterproofing, roofing, sealing and bonding, and other industrial applications.

We know that your business has its own unique flooring requirements in terms of impact resistance, rolling load resistance, wear resistance, safety regulations, antistatic performance, chemical or fire resistance and, increasingly, quick and efficient installation. Because our products can be customized to meet your technical requirements while still complying with government regulations, you're assured of getting excellent solutions that have only the characteristics you want and need.

Sika is a global expert in all core technologies commonly used in our specialty area of seamless flooring. And, all Sikafloor® solutions are developed and manufactured according to industry standards as well as our own strict standards for quality assurance and business ethics. To ensure the perfect solution for your business, we offer several flooring families for you to choose from. The families are based on core technologies. Variations within each family allow you to find solutions fine-tuned to your individual needs. All of the families are bonded together by our core flooring values: seamless solutions for your needs, innovative designs, durable and sustainable performance by offering more value at less impact, and full professional support by expert field personnel who are not only the best at what they do but who also take great pride in their work and care about your project.

We design every seamless Sikafloor® product using liquid-applied synthetics or synthetic-cementitious-hybrids. Our synthetic solutions are ideal for a wide variety of applications which is why you find them in industrial buildings, food and pharmaceutical facilities, car parks, schools, libraries, hospitals, shopping malls, museums, apartment building balconies, private residential properties and other settings.

Our cementitious flooring solutions are designed for ready-to-use and subfloor preparation applications. For time-critical projects, we offer a unique technology that reduces the waiting time for moist concrete to dry - our Sikafloor® EpoCem® intermediate layers can be installed directly on green and damp concrete.



Whether you're a building tenant, owner or applicator, Sika has you covered. In addition to our array of product offerings, we can supply you with industry certifications, proof of product performance and a global network of flooring specialists. For applicators, we also offer training programs to ensure proper installations. We do these things because we believe in Building Trust.

SIKA PRODUCT OFFERINGS:



Sikafloor® MultiDur

Epoxy flooring systems by Sika, a global standard. Your workhorse for heavy-duty performance, these flooring systems offer excellent mechanical strength, wear-resistance and chemical-resistance. Although seamless floors, by definition, are aesthetically pleasing, color and design are typically not our customers' major driver in choosing these flooring options. Rather, functionality and delivering long-lasting performance is where these floors excel. Choose from smooth, textured, broadcasted (slip-resistant) and mortar finishes to ensure the usability, safety and cleaning regime best fitting your needs.

Within the Sikafloor® MultiDur family you will find special solutions with extremely high chemical resistance;

solutions approved for cleanroom usage; and electrostatic discharging, dissipative and electrically conductive flooring. For more basic flooring use and high performance wall coating needs, we offer water-borne coating systems.

Sikafloor® MultiDur solutions are commonly found in:

- Storage, logistics and sales areas
- Production, processing and cleanroom areas (dry and wet)
- Ground-bearing decks, car parks and parking garages
- Commercial, public and residential areas

Sikafloor® DecoDur

Decorative epoxy flooring systems by Sika. These added design options for heavy-duty flooring are perfect for projects where you want more than a traditional, uni-color design and need the performance of an epoxy floor. Within the Sikafloor® DecoDur family, we offer flooring solutions with different grades of mechanical and chemical resistance, all in a speckled design. Patterns range from a granite effect up to a larger full-flake design and are available in a variety of colors.

Typically, Sikafloor® DecoDur floors are installed with a smooth or lightly broadcasted surface texture. At your preference, we can finish the floor with a matte sealer designed to withstand common household and light-industrial chemicals or a tougher, more chemical-resistant, glossy finish.



Sikafloor® DecoDur floors are commonly found in:

- Life science facilities
- Laboratories
- High-pedestrian traffic zones in commercial and institutional buildings
- Food courts



Sikafloor® MultiFlex

Polyurethane flooring systems for heavy duty and industrial usage by Sika. Sikafloor® MultiFlex systems are known for their higher elasticity which allows for crack-bridging designs. Further, these floors excel in absorbing base floor movements.

Sikafloor® MultiFlex solutions include designs installed directly on top of elastic waterproofing membranes and are available with or without special surface protection. These floors are installed in smooth, light broadcast and heavy broadcast (high anti-slip) designs.

Sikafloor® MultiFlex can commonly be found in:

- Storage, logistic and sales areas (raised floors)
- Production, processing and cleanroom areas (dry and wet)
- Car parks, intermediate and top decks

Sika ComfortFloor®

With decorative, polyurethane flooring systems for commercial and residential applications by Sika, perfection has never been so close. Global technology leadership in industrial and resilient flooring comes together in our Sika ComfortFloor® family, offering seamless, high-end aesthetics for even the most discerning clientele. An environmentally friendly solution, Sika ComfortFloor® is mainly based on natural oils and organic raw materials. Its backing – comprised of resilient, acoustic isolation pads – are made of recycled rubber and foam particles.

Sika ComfortFloor® products offer nearly unlimited design freedom. They are typically installed in a matte finish and are available in 72 standard colors. Custom colors are also an option, as are two-tone “concrete-look” designs and the ability to create your own floor art. Additional options include broadcasted colored flakes for a speckled design and



a light, anti-slip surface texture for use in wet areas such as showers and toilet rooms. All products offer very high color stability.

Sika ComfortFloor® solutions are commonly found in:

- Institutional buildings such as schools,

museums, libraries and hospitals

- Commercial buildings such as shopping malls, hotels, office buildings and restaurants
- Residential buildings of high-end, modern design
- Therapeutic, restorative and exercise facilities, such as yoga or spa spaces



Sikafloor® MonoFlex

One-component, polyurethane flooring solutions for easy installations, by Sika. Sikafloor® MonoFlex flooring solutions have earned their excellent reputation based mainly on their performance as a waterproof finish for balconies, walkways and staircases with pedestrian traffic. These moisture-triggered solutions are true innovations in terms of sustainability and ease of application.

Upon request, broadcasted colored flakes can be added for a speckled design. A light or medium anti-slip surface texture can also be provided. All products in this family offer very high color stability.

Sikafloor® MonoFlex solutions are commonly found in:

- Balconies
- Pedestrian walkways and staircases

Sikafloor® PurCem®

Polyurethane cementitious hybrid flooring systems by Sika. These innovative flooring solutions deliver extreme performance in terms of mechanical and chemical resistance as well as reduced environmental impact. Because they're durable, low maintenance and available with resurfacing options, our versatile Sikafloor® PurCem® range of products is gaining global appreciation and can be found in a wide variety of heavy-duty applications. The special core technology of an elastic resinous binder reacting with cementitious fillers is what makes this product family resistant to high temperature variations, even thermo shocks for certain designs. Installation on damp concrete surfaces is possible with Sikafloor® PurCem®.

Typically, Sikafloor® PurCem® floors are installed in a light or heavy anti-slip broadcast or in a full mortar build-up to ensure high performance in wet areas. A smooth/light-textured surface finish is available for dry areas.

Sikafloor® PurCem® Gloss is the latest innovation to our Sikafloor® PurCem® family. This product's glossy finish allows for significantly easier floor cleaning. Specified with a smooth surface finish and in a low- to medium- thickness, this solution can be an alternative to some Sikafloor® MultiDur products.

Sikafloor® PurCem® solutions are commonly found in:

- Food and beverage processing facilities
- Professional kitchens
- Cool storage areas
- Heavy-duty processing areas, especially wet processing



Sikafloor® Pronto

Methacrylate (P.M.M.A.) flooring systems that speed up installation times to the maximum, by Sika. Our Pronto family is known for its high resistance to a wide variety of uses. The super-fast curing time of these synthetics allows for super-quick refurbishments, though proper ventilation is required during installation to avoid inconveniences from odors.

When applied to areas with pedestrian traffic, Sikafloor® Pronto surfaces are typically installed in a smooth or light broadcast finish. A colored-flake broadcast finish can be provided upon request. A heavier broadcast finish is available for applications where there is vehicle traffic.



Sikafloor® Pronto solutions are commonly found in:

- Commercial kitchens

- Processing areas
- Pedestrian walkways, such as balconies and staircases

- Animal facilities
- Multi-story and underground car parks

Sikagard® WallCoat

A wall coat that blends specific, engineered performance requirements with decorative designs, by Sika. When you

need more than just paint, our family of Sikagard® WallCoat performance and decorative wall coating systems delivers unique benefits for demanding surface

finishing, including chemical resistance and heavy-duty mechanical resistance.

Our wall coat has the ability to withstand chemicals used in cleaning regimes and in-film preservatives providing finishes that do not promote the development of fungi, bacteria and other micro organisms. Our wall coat systems come in an array of colors, many of them match specified Sika flooring product colors. Sikagard® WallCoat solutions do it all easily.



Sikagard® WallCoat solutions are commonly found in:

- Cleanroom certified areas
- Food and beverage processing facilities
- Hospitals and laboratories
- Concrete surface protection
- Tunnels
- Commercial, institutional and residential interior finishing



Sikafloor® HardTop

Concrete surface hardening, curing and sealing and heavy-duty industrial screeds, by Sika. Our dry shake Sikafloor® powders are broadcasted directly onto the fresh concrete – before the powerfloat finish is applied – to create an extremely hard-wearing, monolithic concrete floor. Additional performance can be achieved through various liquid-applied surface hardeners, curing compounds and surface sealers.

Sikafloor® HardTop solutions are commonly found in:

- Storage, logistics and sales areas
- Non-critical, heavy-duty industrial areas such as dry processing facilities
- Car parks, parking garages

SikaCeram® StarGrout

SikaCeram® StarGrout is the new generation of epoxy grout classified R2T and RG according to the tile adhesive Standard EN 12004 and the tile grout Standard EN 13888. This premium tile grout is suitable for grouting all kinds of ceramic tiles, mosaic, marble and natural stone, for both interior and exterior use on joints between 1 and 15 mm. Thanks to its extremely high mechanical and chemical resistance it is a perfect choice for places where absolute hygiene plays a deciding role, in either residential or commercial areas such as swimming pools, laboratories, industrial kitchens or the food industry.

This new product offers great benefits to the tile setter and craftsman, e.g. outstanding workability, easy to clean off, reduced odor, long lasting, plus a

perfect finish with the neutral silicone Sikasil® C with the same color, name and shade.





Sika® FloorJoint

The sound and feeling of rumbling over crossing joints in warehouses and trafficked areas is familiar to most people. It can feel uncomfortable and cause irritation for ears and body. Innovative joint panel Sika® FloorJoint offers the perfect solution with ultra-thin and almost invisible joint profiles for reducing the noise and vibration over the joints. The profiles are installed on the same surface level as the floor, which means no thresholds. Another functional benefit of the system is the reduction of impacts on the vehicles crossing the joint, meaning the significant cost saving in spare parts and maintenance of the forklifts.

Sika® FloorJoint has two profile options, Sika® FloorJoint PD and S, which are compatible with Sikafloor® flooring

systems and can also be made watertight by using Sikadur® Combiflex SG System. The installation of the panels is easy and fast providing extremely short downtime. The system fits perfectly to fast space refurbishment jobs. Sika® FloorJoint systems have good chemical resistance, are totally seamless to surrounding floor surface and absolutely corrosion-free, perfect solution for food processing environment.

Main uses in:

- Warehouses
- Industrial floors
- Parking areas
- Commercial and public buildings



FULL RANGE SOLUTIONS FOR A WATERTIGHT AND SECURE BUILDING ENVELOPE

1. HIGH PERFORMANCE ADMIXTURES FOR CONCRETE

Concrete structures and elements including the foundation, basement, walls, columns, beams and floor slabs form the main part of the overall building envelope. Sika's solution includes concrete admixtures which increases the performance factors of such concrete components, such as strength, workability, watertightness and many other features. Sika experts also provide tailored solutions for architects to create special design effects when specifying concrete as a key visual design element in their projects.

2. WATERTIGHT BASEMENTS AND OTHER BELOW GROUND STRUCTURES

In food and beverage facilities, the ground bearing areas need to be waterproofed. Sika has over 100 years of experience in providing waterproofing solutions. The selection of the most appropriate waterproofing concept and system for any specific project is dependent on many factors, and it is important to involve a qualified waterproofing specialist at the early stages of design. Your local Sika Technical Services Department can provide expert advice and proper solutions to all your problems.

3 & 4. SEALING AND BONDING FOR WATERTIGHT FACADES AND WINDOW INSTALLATION

Energy efficiency requirements for exterior walls are becoming more stringent, strongly influencing building standards worldwide. Sika has developed sealing and bonding technologies and systems for facades to help designers meet higher energy efficiency and environmental requirements, whilst ensuring safe, economical installation and also reducing overall construction time. Sika works in close cooperation with leading facade designers and manufacturers using the latest material technologies for all types of facade construction.

5. CORROSION AND FIRE PROTECTION OF STEEL STRUCTURES

Steel structures in buildings all need to be protected against corrosion caused by exposure to the surrounding environment. In manufacturing facilities, they also have to meet stringent building regulations for fire protection.

Sika has a proven track record of providing durable and reliable corrosion and fire protection coatings on steel structures for over 50 years. Our coating systems are available in different colors and comply with the latest National and International Standards including ISO EN 12944 for steel corrosion protection, and ISO EN 13381-8 for fire protection.

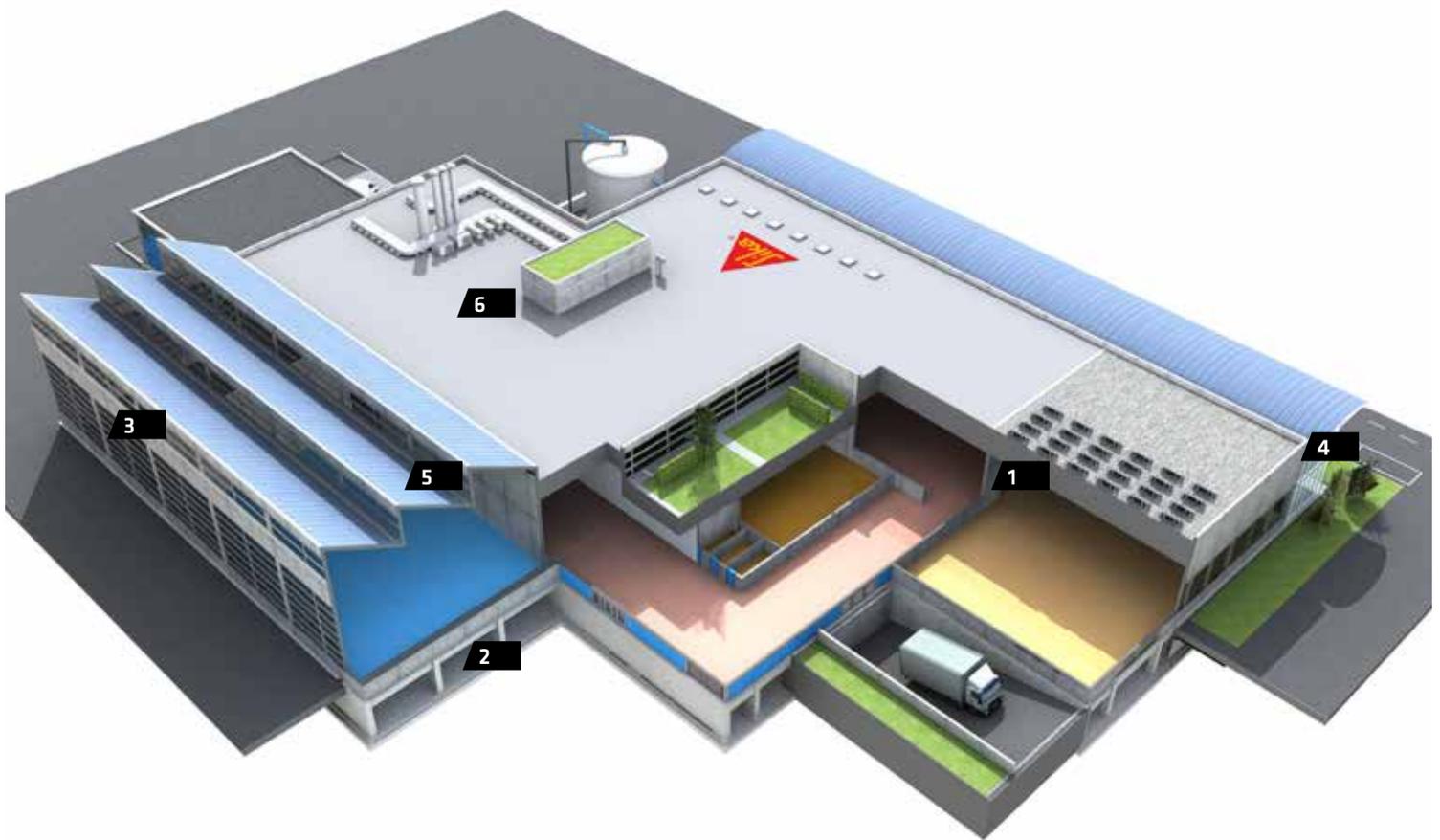
6. DURABLE AND LONG LASTING ROOFING

A long-lasting watertight roof is essential for the reliable operation and sustainability of a plant. Rain, snow, wind uplift forces, sun light, and many other environmental influences can cause failure of the roof system. This results in leaking and damage which require costly repairs, and possibly re-roofing. As the global leader with a proven record of over 50 years, Sika produces high quality and long-lasting Sarnafil® and Sikaplan® polymeric membranes, plus SikaRoof® MTC liquid applied membrane that meet the specific needs and budgets of roofing for health-care facilities.

Sika supplies solutions for the new-build and refurbishment of the following roofs:

- Exposed roofs
- Gravel ballasted roofs
- Green roofs
- Helipads
- Solar roofs
- Balconies

INTERIOR ENVIRONMENTS CAN ONLY RUN PERFECTLY WHEN PROTECTED BY A PERFECTLY TIGHT BUILDING ENVELOPE. TAKE CONTROL OF YOUR ENVIRONMENT WITH BUILDING ENVELOPE SOLUTIONS FROM SIKA.



SOLUTIONS FOR:

1
Admixtures for concrete

2
Basement waterproofing

3
Sealing and bonding for glazed facades

4
Facade joint sealing/Window installation

5
Fire and corrosion protection for steel structures

6
Roofing

SIKA AS A RELIABLE AND INNOVATIVE PARTNER IN CONSTRUCTION AND REFURBISHMENT

Sika is a specialty chemicals company with a leading position in the development and production of systems and products for bonding, sealing, damping, reinforcing, and protection in the building sector and the motor vehicle industry. Sika has subsidiaries in more than 100 countries around the world and manufactures in over 200 factories.

100 YEARS OF EXPERTISE

Our reputation for quality and reliability is virtually unmatched, and is illustrated through a comprehensive portfolio of problem solving products that have been employed for many years in a diverse range of applications. Whether we are waterproofing your basement or your roof, protecting your floors and wall, sealing your skyscraper or your car, or working with you on your building, you will see why we are renowned for Building Trust. For the full range of solutions from basement to roof, please refer to our brochure on manufacturing facilities.

WORLDWIDE PRESENCE FOR CUSTOMERS

Sika has a long track record of success as a complete system and problem solution provider on many different food & beverage facility projects all around the world. Please visit the “reference” section on www.sika.com to see a selection of these projects. With extensive technical expertise and solid practical experience on every continent and in all types of climate and environments, Sika is a highly qualified and reliable partner for all of your projects. Sika has highly professional technical and sales teams to support our customers and their clients. These teams include qualified engineers and technicians with expertise in all of the relevant technologies and applications, together with technical service engineers that have extensive practical installation and on-site training expertise to help ensure that the work is completed correctly and is ‘right the first time.’

WHAT MAKES SIKA SUCCESSFUL IS THE COURAGE FOR INNOVATION

873 employees globally are dedicated to research and development. Sika’s success and reputation is based on our long-lasting tradition of innovation.

Accordingly, the core of Sika business is the innovation management and the focus on developing quality products and the best solutions for customers. Sika Technology AG in Switzerland takes the lead in long-term research programs for the whole Sika Group, whilst the responsibility for the development of new solutions sits with our 20 Global Technology Centers plus 18 Regional Technology Centers worldwide. New products and systems are also developed on a regional level to meet local markets’ specific needs and requirements.

MORE VALUE, LESS IMPACT

Sika is committed to pioneering sustainable solutions to address global challenges, and to achieve this safely at the lowest impact on resources. Creating and increasing value while reducing impacts – that is the goal. Our strategy fully integrates sustainability into all of our business processes, and we strive to create value for our customers and partners along the whole supply chain and throughout the lifespan of our products. The value created far outweighs the impacts associated with production, distribution and use.

KASPAR WINKLER
FOUNDED SIKA IN

1910

SIKA HAS PROVIDED WATERPROOFING
SOLUTIONS FOR

100+ YEARS

THE FIRST PRODUCT - Sika®-1 -
IS STILL ON THE MARKET

EVERY YEAR SIKA SUPPLIES ENOUGH ROOF
MEMBRANES TO COVER THE

**WHOLE OF
MANHATTAN**

CORE COMPETENCIES:

**BONDING, SEALING, DAMPING, REINFORCING
AND PROTECTING LOAD-BEARING STRUCTURES**

IN BUILDING AND INDUSTRY.

SIKA HAS WORLDWIDE

**20 TECHNOLOGY
CENTERS**

EVERY YEAR SIKA FILES

**70+ NEW PATENT
APPLICATIONS**

SIKA'S CLEANROOM FLOORING SYSTEMS RELEASE

**1,000 TIMES
LESS EMISSIONS**

THAN STANDARD LOW VOC SYSTEMS

200+ AWARDS

FACTORIES WORLDWIDE

SIKA HAS SUBSIDIARIES IN

100+ COUNTRIES

AROUND THE WORLD

SIKA HAS

**18,000+
EMPLOYEES**

SIKA ACHIEVED TOTAL SALES OF

**CHF 6.25
BILLION IN 2017**

BUILDING TRUST



ALSO AVAILABLE FROM SIKA



FOR MORE SIKA FLOORING INFORMATION:



WE ARE SIKA

Sika is a specialty chemicals company with a leading position in the development and production of systems and products for bonding, sealing, damping, reinforcing and protecting in the building sector and the motor vehicle industry. Sika's product lines feature concrete admixtures, mortars, sealants and adhesives, structural strengthening systems, industrial flooring as well as roofing and waterproofing systems.

Our most current General Sales Conditions shall apply. Please consult the most current local Product Data Sheet prior to any use.



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BUILDING TRUST

