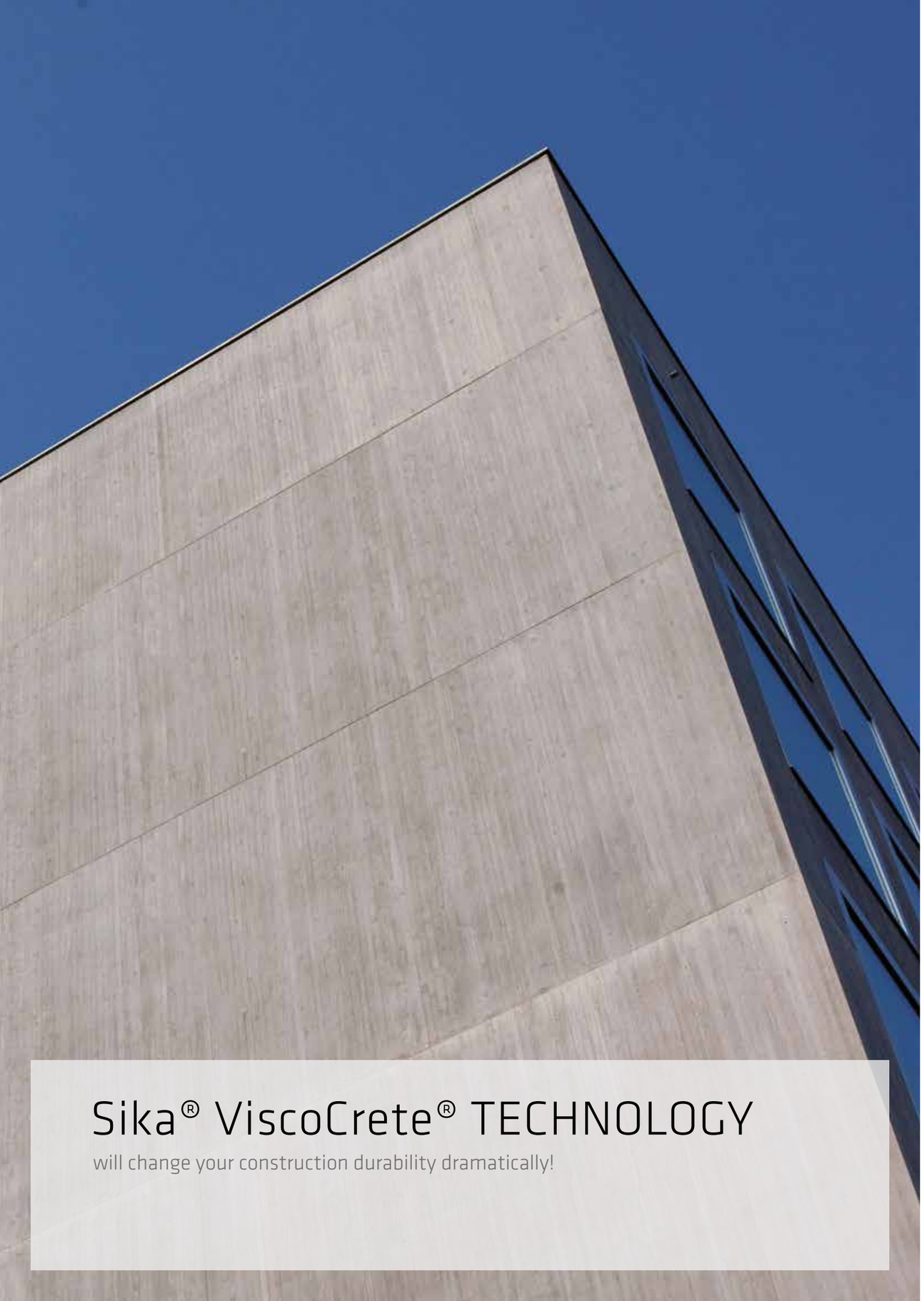
CONCRETE
Sika® ViscoCrete® TECHNOLOGY

BUILDING TRUST



Sika® ViscoCrete® TECHNOLOGY

will change your construction durability dramatically!

CONTENTS

CONCRETE TECHNOLOGY

Significant water content reduction results in enhanced durability properties of the hardened concretes

The engineering of concrete structures is a continuous developmental process. Invention and development of new construction methods place ever higher demands on building materials. Concrete producers face this technological challenge daily alongside other factors such as economy, ecology, raw material and energy costs as well as increased logistical complexity. In the duration of the whole construction process time itself also becomes an increasingly important factor.

Sika® ViscoCrete® technology brings several innovative options to concrete mix design. A major characteristic is the capability to substantially reduce the water content of a mix. Achievement of lower water/cement-ratios (w/c-ratios) results in dramatically enhanced durability, induced by remarkably low concrete permeability. Application of more economical mix designs is another option, with optimizations yielding more ecological and resource-friendly mixes at constant concrete quality.

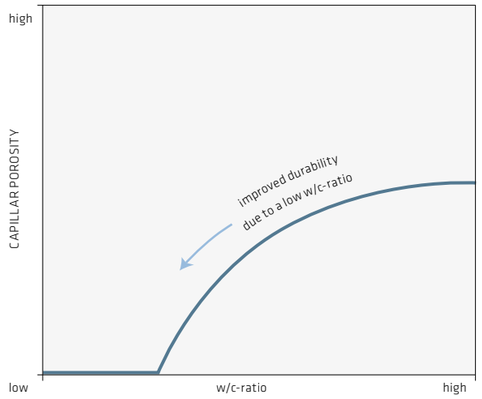
Sika® ViscoCrete® technology responds to the current trend to use flowable concrete types. The trend demands new admixture technologies, and Sika® ViscoCrete® offers solutions for production of flowable concrete types for ready mix, onsite production and for the precast concrete industry. The target is to produce concrete with high flowability sufficient for a period of time and with no negative side effects. Extended workability, controlled over several hours and without retardation is especially important for urban construction sites with congested traffic, or in remote areas resulting in long transportation times. Sika® ViscoCrete® technology also meets the challenge of ensuring target consistency in a concrete mix in high-temperature climates.

Strength gain is a present and continuous challenge in concrete technology and the construction business. All participants in the construction process desire achievement of sufficient early strength to allow formwork removal as quickly as possible, whether on construction sites or in production of precast concrete. In industrialized precast concrete production, early strength development is crucial because it influences the entire production process. High early strength development in concrete results in fast turnaround of formwork in a precast factory, in reduced or omitted heat or steam curing, more economical and ecological concrete mix designs, and earlier cutting of prestressing tendons.

CONCRETE TECHNOLOGY

IMPROVED DURABILITY WITH LOW CAPILLARY POROSITY

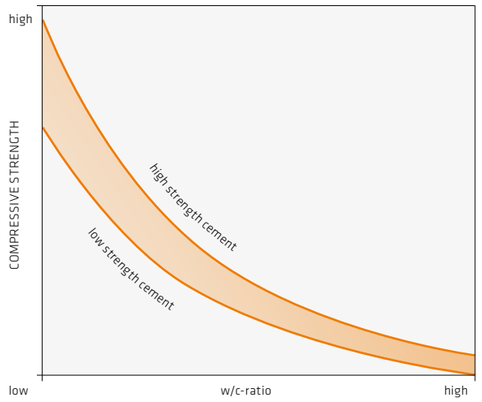
As durability and sustainability of constructions become more important, these properties must be considered in design of concrete. The w/c-ratio has a crucial influence on the impermeability of any concrete matrix. Application of Sika® ViscoCrete® can dramatically increase impermeability of any concrete matrix. A specific amount of water is necessary for a complete hydration and additional water will produce capillary pores which will have an influence on the compressive strength and density of the concrete. The application of Sika® ViscoCrete® will allow to reduce the amount of water and therefore can dramatically increase the impermeability of the concrete.



ENHANCED STRENGTH DUE TO LOWER W/C-RATIO

W/c-ratio and obtainable compressive strength stand in a materially factual relation. The w/c-ratio is therefore the decisive factor influencing strength gain.

Because of this relation, any strength increase in fresh concrete leads to reduced workability without addition of an admixture. On the other hand, targeting easy flowability of fresh concrete through addition of water consequently reduces compressive strength, and risking the durability of the hardened concrete.

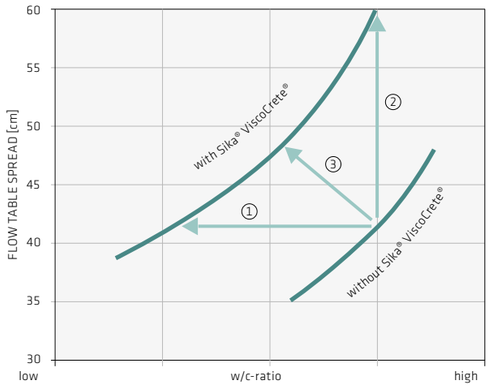


Sika® ViscoCrete® SURMOUNTS NATURAL LIMITS

With the application of Sika® ViscoCrete® it is possible to produce concrete which reaches substantially higher strength classes by reducing the w/c-ratio at a defined flowability (1).

Furthermore the design and production of a more flowable concrete at constant compressive strength can be realized with Sika® ViscoCrete® (2).

Last but no least with the Sika® ViscoCrete® technology it is possible to target both effects simultaneously: higher strength in conjunction with improved fresh concrete behavior (3).

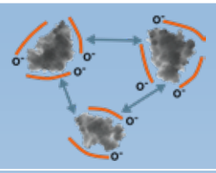
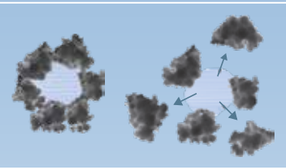
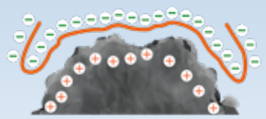
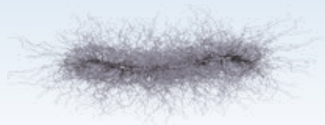


POLYMER AND PRODUCT TECHNOLOGY

Overview

The workability and w/c-ratio of concrete can be improved by the use of water reducing admixtures and high range water reducing admixtures. Various materials have been used for this purpose in the history of concrete. Traditional technologies like ligno sulphonate, gluconate, naphtalene, melamine or vinyl copolymers are limited in their abilities to reduce the water reduction rate. The newest generation of water reducing admixtures is based on modified polycarboxylates or polycarboxylate ether (PCE). This new PCE technology exceeds the traditional technologies in many ways, specifically in water reduction abilities, workability and slump life.
Sika has launched different product ranges based on the PCE technology like Sika ViscoFlow®, SikaPlast® and Sika® ViscoCrete®. Typically these products combine different Sika® ViscoCrete® polymers and other raw materials to match the customers requirements.

Advantages of PCE technology:
- Better water reduction
- Better workability
- Better slump life
- Better compatibility
- Better early strength
- Better cost/performance

Ligno Sulphonates		■ electrostatic inter particle repulsion ■ reduced surface tension ■ retarding ■ water reduction up to 10%	low water reduction
Gluconates			
Naphthalenes **Melamines**		■ electrostatic inter particle repulsion ■ water reduction up to 20%	
Vinyl copolymers		■ electrostatic inter particle repulsion ■ water reduction up to 25%	
PCE		■ electrostatic inter particle repulsion ■ steric hindrance ■ water reduction up to 40%	high water reduction

Sika® ViscoCrete®
POLYMER TECHNOLOGY

CHARACTERISTICS AND ADVANTAGES OF POLYCARBOXYLATE ETHER TECHNOLOGY (PCE)
The major characteristic of polycarboxylate ether-based superplasticizer technology is its targeted polymer design to achieve specific concrete properties. The mode of action is based on the adsorption of the PCE onto the cement grain and dispersion of the particles by steric hindrance.

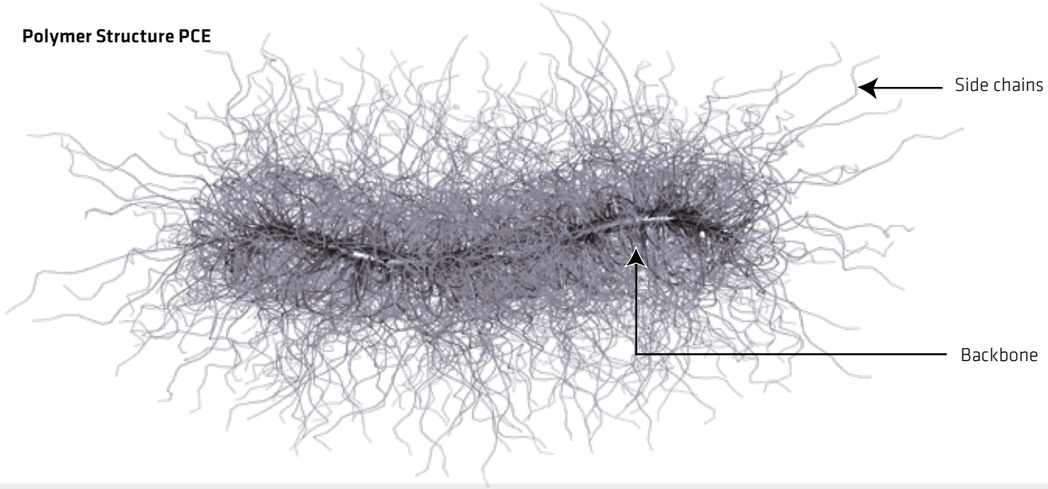
Characteristics that can be influenced are:
- Adsorption speed
- Water reduction with high initial liquefaction / workability
- Slump retention without retardation and subsequent fast strength development
- Early strength development with sufficient workability time
- Stickiness
- Stability / viscosity

Various combinations of these properties can be optimized.

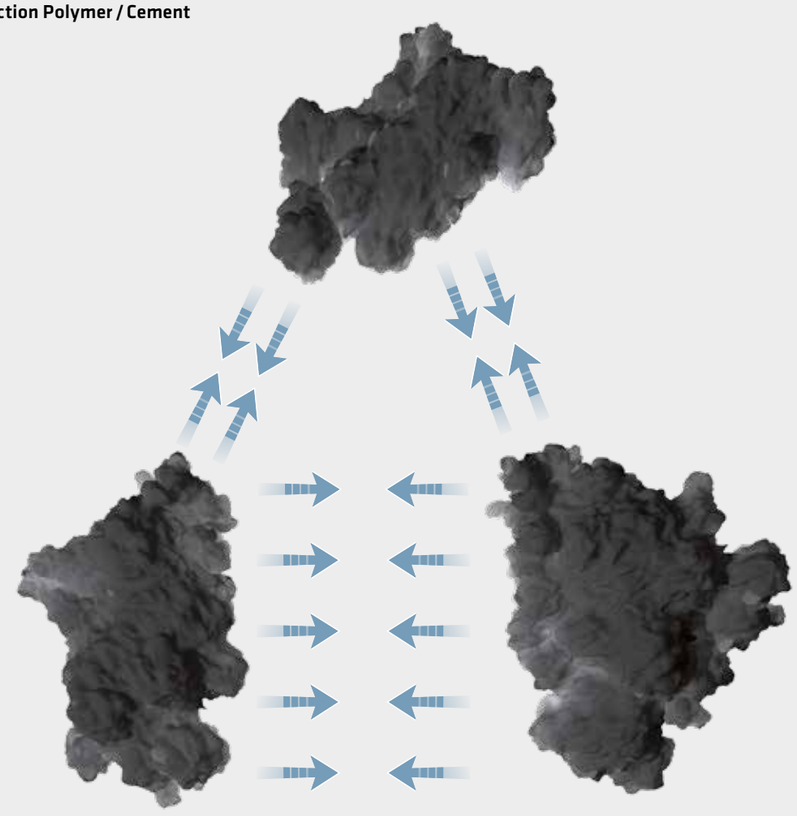
The polymers consist of backbones with carboxyl groups and side chains.

The first component – backbone with carboxyl groups – is responsible for the attainable water reduction / initial slump and mixing time respectively. The second one – side chains – determines the slump keeping capability of the superplasticizer, affected by an increasing number of side chains. The crucial factor is the limited space for carboxyl groups and side chains along the backbone. Either a carboxyl group or side chain can be attached at a certain location. Basically variations in those factors lead to three generic types of polymers:
water reducing, slump controlling and slump retaining polymers.

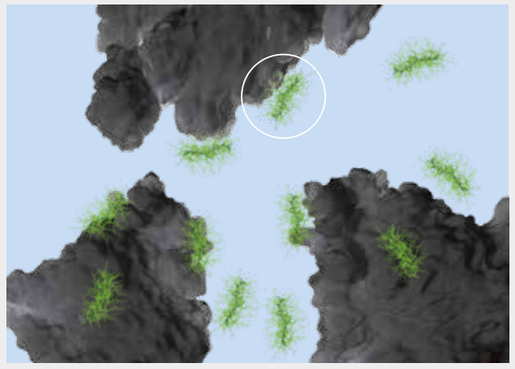
Polymer Structure PCE



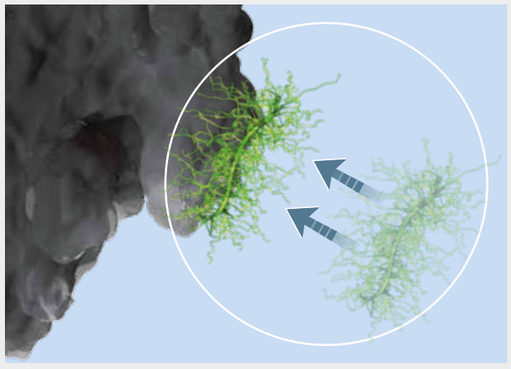
Interaction Polymer / Cement



Mutual attraction of cement grains.

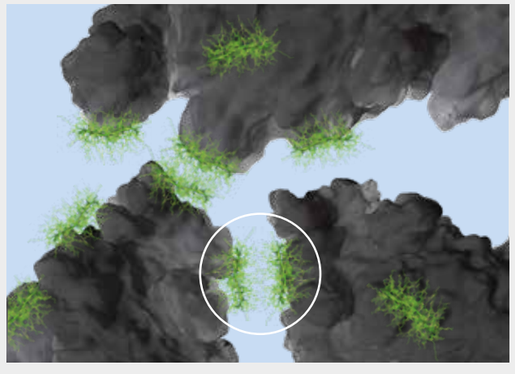


Adsorption of the polymer (backbone) on the cement grain.

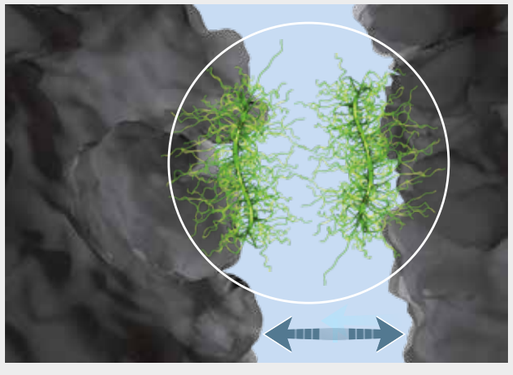


Detail of the adsorption of the polymer (backbone) on the cement grain.

Improved workability due to steric hindrance.



Detail of improved workability due to steric hindrance.



Sika® ViscoCrete®
PRODUCT TECHNOLOGY

It is possible to design a PCE with a large number of carboxyl groups and consequently low number of side chains, leading to high water reduction and shorter slump life of the concrete (**Water Reducing ViscoCrete® Polymer**).

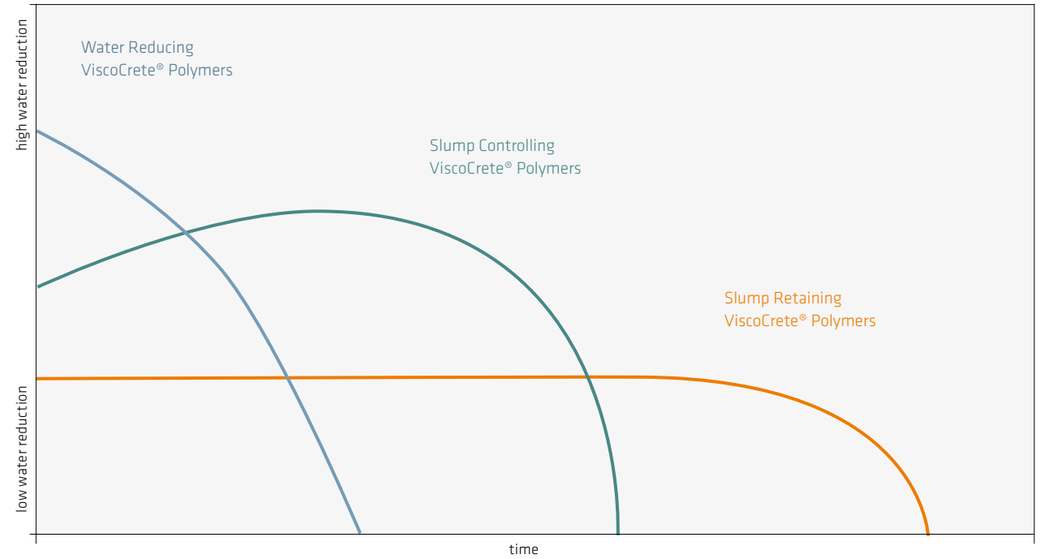
Another possibility is to have a large number of side chains resulting in lower water reduction and longer slump life. These type of PCE work by creating a certain depot effect which results in an extended slump retention (**Slump Retaining ViscoCrete® Polymer**).

The third possibility is to design PCE which are able to change their sturcture in concrete over time. This special behaviour causes a delayed dispersion effect. Such kind of specifically designed polymer can be used for slump controlling (**Slump Controlling ViscoCrete®Polymer**).

The Sika® ViscoCrete® technology offers more than the possibility to design PCE polymers with specific properties. It enables combination of various polymers to exploit the potential of each one. This compatibility is a major advantage of Sika® ViscoCrete® technology: tailor made solutions can be developed and adapted to the performance of the concrete mix. Moreover final products can be optimized with regard to local market requirements to yield the best cost-performance solution.

Key-Performance Drivers:
- Water reduction
- Slump retention
- Setting time
- Costs
- Stability
- Robustness
- Smoothness

Raw Material Characteristics:
- Cement
- Aggregates
- Additives



REQUIREMENTS AND APPLICATIONS

A highly flowable concrete helps simplify the entire construction process

Requirements
The specification of a certain compressive strength of the hardened concrete usually ensures the functionality of a standard. Durability and lifetime as increasingly important factors, on the other hand, are determined by minimum cement content and maximum w/c-ratio. These two factors, which influence strength and durability decisively, are normally associated with a workability of fresh concrete sufficiently adjusted through application of a superplasticizer.

The speed of the whole construction process is gaining importance, because fluid concrete implies:
- Fast casting
- Fast discharge of mixer and truck
- Easy placing and compaction
- Good surface finish,
  which results in overall reduced effort and time saving.

These factors are leading to higher requirements regarding:
- Early strength development with sufficient slump life
- Fast stripping time with efficient formwork operation
- Cost control of material, energy, logistics and manpower

Concrete with sufficient workability from batching plant to compaction leads to higher quality, as there is no need for redosage of superplasticizer. The durability is increased as the probability of defects and blowholes is significantly reduced.

Sustainability of concrete structures does not only imply prolonging the durability of concrete and with this the service life of a construction. Moreover engineers involved in the design of concrete have to take into consideration the carbon footprint of the production of a concrete mix. The limitation of carbon dioxide emission for the production of concrete can be realized with the following measures:
- Optimization of binder content
- Application of blended cement
- Usage of secondary cementitious material
- Increased application of filler
- Use of recycled aggregates

In order to produce concrete that is as resource-friendly as possible while fulfilling all technological requirements, it is necessary to make use of sophisticated superplasticizer technology.

The use of Sika® ViscoCrete® as a high performance superplasticizer based on PCE technology is virtually mandatory to target higher strength classes, fresh concrete with greater flowability, and sustainable concrete production.

Applications
The Sika® ViscoCrete® technology offers solutions for all application fields within the concrete industry – ready mixed concrete, precast concrete or site-batched concrete. Sika® ViscoCrete® achieves the ideal solution for your concrete challenge. Various construction process participants may have different requirements depending on their daily focus. Sika® ViscoCrete® adapts to these demands.

REQUIREMENTS AND APPLICATIONS

OWNER

REQUIREMENTS
An owner who enlists a designer to develop a structure focuses initially on the investment and maintenance cost in combination with the speed of construction.

This implies:
- High concrete durability and quality
- Slender dimensions of structural members
- Aesthetics with fair faced concrete appearance
- Application of innovative fast construction methods

SOLUTIONS
To achieve the aims listed, a technological challenge will be powerful water reduction in the concrete mix; this will result in increased impermeability leading to higher quality and durability.

Sika® ViscoCrete® technology offers this as well as:
- High Strength Concrete and Ultra High Strength concrete
- Fair-faced concrete with outstanding flowability
- Resource friendly building materials, i.e. optimized concrete mix
- Self Compacting Concrete for slender structures and fast construction process

DESIGNER

REQUIREMENTS
A concrete construction designer is constantly looking for new construction methods and technological possibilities in order to make full use of all different material properties leading to cost efficient and timely construction.

Furthermore importance is attached to:
- Appearance and aesthetics; these are the designer's calling card
- Prevention of cracks, especially due to shrinkage
- Resource friendly design methods
- Ecologically sustainable building materials
- High concrete quality offering high durability with low maintenance

SOLUTIONS
The ability to resist the ingress of pollutants enhances the durability of concrete, thereby guaranteeing the engineering properties of the concrete structure for an extended period.

The Sika® ViscoCrete® technology offers solutions for this challenge including:
- Impermeability of the hardened concrete facilitated by outstanding water reducing capability
- Significant shrinkage crack reduction
- Excellent flowability producing smooth, dense surfaces
- Development of cost efficient, sustainable concrete mixes
- Design of watertight concrete, and frost and freeze/thaw resistant concrete

CONTRACTOR

REQUIREMENTS
In the construction process the contractor carries out the last part of this process onsite; it should be as easy, fast, safe and cost efficient as possible. Therefore the contractor has highest interest in concrete properties directly influencing the construction process.

This direct link means:
- Sufficient workability offering easy and fast placing and compaction
- Constant fresh concrete properties even in different ambient conditions, e.g. high temperatures
- Time saving
- Short stripping times and fast turnaround of formwork
- Greatly improved working conditions

SOLUTIONS
The vital property of sufficient workability can be achieved with Sika® ViscoCrete® technology; it offers high liquefaction power, extending workability with no retardation effects.

Moreover this technology offers:
- Installation with necessary flowability and subsequent fast early strength development
- Water reduction enabling economical mix designs
- Fast construction process with pumpable concrete
- Self Compacting Concrete offering fastest installation rates, easy handling and omission of vibration work

SUSTAINABILITY AND COST OPTIMIZATION

The production of resource friendly concrete mixes is becoming more and more important

The design of concrete is more than merely a technical issue; it inevitably also deals with finding cost-efficient raw materials and developing ecologically friendly concrete mix designs. Concrete, as a five-component material, offers numerous parameters for change and thus for influencing concrete performance in the fresh or hardened state. Additionally the interaction of all materials used as well as the demand to take ecological issues more and more into consideration makes the design of concrete a daily challenge.

In the past the driving factor for concrete mix design was to develop a concrete mix that complies with standards and fulfills the requirements at minimum cost. With changing ecological specifications and restrictions the production of resource friendly concrete mixes is becoming more and more important, and with this the sustainable use of raw materials is needed. But this aim does not only refer to optimized use of binder, it is also essential to question all constituent materials incorporated in the mix.

Example – sand replacement in Ready Mix Concrete, Ireland
Natural sands from glacial deposits in Ireland are becoming scarce; it is thus difficult to receive permission to extract natural sands. Consequently concrete plants have to source sand from a number of locations, and therefore variations in material characteristics can occur. Besides that many ready mix concrete plants are located in or near rock quarries where dust (crushed rock fines) is a by-product of the aggregate production process.

The use of stone dust material is therefore a reasonable approach although undesirable properties can be the consequence. The fine aggregate causes unsmooth grading curve, irregular particle shape and excess fine fraction, which leads to increased water demand as well as poor placing and finishing characteristics of the concrete. To compensate for this, the application of a high quality, sophisticated superplasticizer balances increased water demand and enhances rheology to improve placing and finishing characteristics.

In this specific example the natural sand should be changed to crushed sand. The target was to achieve equal fresh concrete behavior regarding workability as well as finishing and hardened concrete properties concerning compressive strength and durability respectively.
These challenging technological requirements could be fulfilled with the application of Sika® ViscoCrete®, in detail the resulting hardened concrete compressive strengths are indicated in the table below.

Replacement of natural sand by crushed rock fines

Strength Class	50% replacement	100% replacement
25 MPa	41	41
30 MPa	43	43
35 MPa	53	53
40 MPa	63	57

Compressive strength in N/mm² with sand replacement in %

With half the price for the crushed sand compared to the natural sand the saving potential per cubic meter concrete is as follows:

Sand Cost	**9.00 €**	per tonne
Crushed Sand Cost	**4.50 €**	per tonne
Consumption	**0.75**	tonnes per m³ concrete
Savings	**3.38 €**	m³ concrete
Additional Admixture Costs	**1.15 €**	m³ concrete
Net Savings	**2.23 €**	per m³ concrete

In order to keep the required fresh and hardened concrete properties it was necessary to use the Sika® ViscoCrete® high performance superplasticizer. This led to some additional cost for the admixture which was more than compensated by the huge savings resulting from the more cost-efficient crushed sand.

Sika® ViscoCrete® SOLUTIONS

References

GOTTHARD BASE TUNNEL, SWITZERLAND

PROJECT

The Gotthard Railway Tunnel is 57 km long and consists of two single line tubes which are connected every 325 meters. The system of all tunnels, access tunnels and connections has a total length of 153.5 kilometers. The opening of the Gotthard tunnel was in 2016.

REQUIREMENTS

Due to the logistics onsite and the long transportation distance a good workable concrete up to 7 hours is needed. To follow the pace of TBM a fast setting after placing the concrete is required. In addition to these main tasks, the concrete should be not too sensitive to the hot climate and the aggregates fabricated from the excavated tunnel material. Overall a service life of 100 years is requested.

Sika® ViscoCrete® SOLUTION

Sika was active in 3 of the 5 sections in the Gotthard Base Tunnel Project. Sika fulfilled the high requirements regarding fresh and hardened concrete characteristics and supplied more than 5'000 tons of customized superplasticizers Sika® ViscoCrete® to the construction site. The Sika® ViscoCrete®-Technology was used for various applications:

- Long time retarded Shotcrete
- Concrete for the inner lining with extended workability time and high early strength development
- Invert concrete with extended workability time and high early strength development

FREEDOM TOWER, USA

PROJECT

The Freedom Tower or One World Trade Center was a high-rise building project being erected on the location of Ground Zero, where the World Trade Centre was located until its destruction on September 11, 2001. The total height of the building was projected to reach 1'776 feet, which is equal to 514 m, and represents the year of declaration of US independence. The construction time was scheduled from 2006 – 2013 and after its completion the 114 floors will offer a total space of 250'000 m^2. The overall concrete volume amounts to 230'000 m^3, whereas the superstructure consists of 190'000 m^3 concrete being installed within the construction time. The opening of the One World Trade Center was in November 2014.

REQUIREMENTS

Several different high strength concrete types are needed to fulfil the changing requirements with increasing construction height. Concrete installed at the bottom in the first five floors has to reach a compressive strength of 96 MPa and as the building progresses the mix design will be altered for lower compressive strength to 83 MPa, 70 MPa and 60 MPa, respectively. Due to the complicated and intricate reinforcement the application of self-compacting concrete is mandatory with a very low w/c-ratio of 0.27, which is necessary to reach the target high compressive strength.

Sika® ViscoCrete® SOLUTION

The Sika solution to the challenging fresh and hardened concrete requirements is the use of Sika® ViscoCrete®-2100. With its substantial water reducing capability the requested high flowability of the fresh concrete can be ensured at a w/c-ratio of 0.27. With the Sika® ViscoCrete®-Technology it is possible to reach a slump flow spread of 700 mm, which can be maintained for more than one hour.

Sika® ViscoCrete® SOLUTIONS

References

METRO SHANGHAI, CHINA

PROJECT

The Metro Shanghai is a 13.5 billion € infrastructure project with a total of 300 km of tunnel constructed with Tunnel Boring Machines (TBM). This 300 km extension of the Shanghai Metro system is part of a government long-term plan with a total of 970 km subway extension.

REQUIREMENTS

In order to ensure a constant supply of this huge number of tunnel segments needed for such an outstanding infrastructure project the early strength development of the concrete being applied is of great importance. The concrete has to reach an early strength of at least 22 MPa after 24 hours including steam curing. Furthermore with optimized concrete mix designs as well as innovative superplasticizer technology the steam curing time should be optimized. Regarding fresh concrete performance a high water reducing capability of the superplasticizer is required to ensure sufficient workability at low water / binder ratio of 0.34.

Sika® ViscoCrete® SOLUTION

With the application of Sika® ViscoCrete®-20 HE 20 it was possible to reach the target workability with a slump life of 15 minutes in combination with a low stickiness of the fresh concrete at a water/ binder ratio of 0.34. Furthermore the significant liquefaction power of Sika® ViscoCrete®-20 HE 20 enabled shortening of the steam curing time by one hour, saving energy resources. The production process consequently became more cost-efficient regarding energy consumption as well as wear and tear of molds. In addition to Sika® ViscoCrete®-20 HE 20, the product was adapted to changing production circumstances, with which the concrete properties could be kept constant and a efficient production could be ensured. More than 150'000 concrete tunnel segments were successfully produced representing a volume of 1'115'000 m^3 concrete generating a consumption of 4'600 tones of Sika® ViscoCrete®.

HOSPITAL OF BRASSCHAAT, BELGIUM

PROJECT

The hospital of Brasschaat had planned to expand their facilities with an X-ray room. In order to protect visitors and employees against the radiation the concrete has to be very dense and impenetrable. For such radiation shielding usually heavyweight concrete is used. Heavyweight concrete uses heavy natural aggregates such as barytes or magnetite or manufactured aggregates such as iron ore and/or lead shot. The density depends on the type of aggregate used and can achieve between 3'000 kg/m^3 and close to 6'000 kg/m^3.

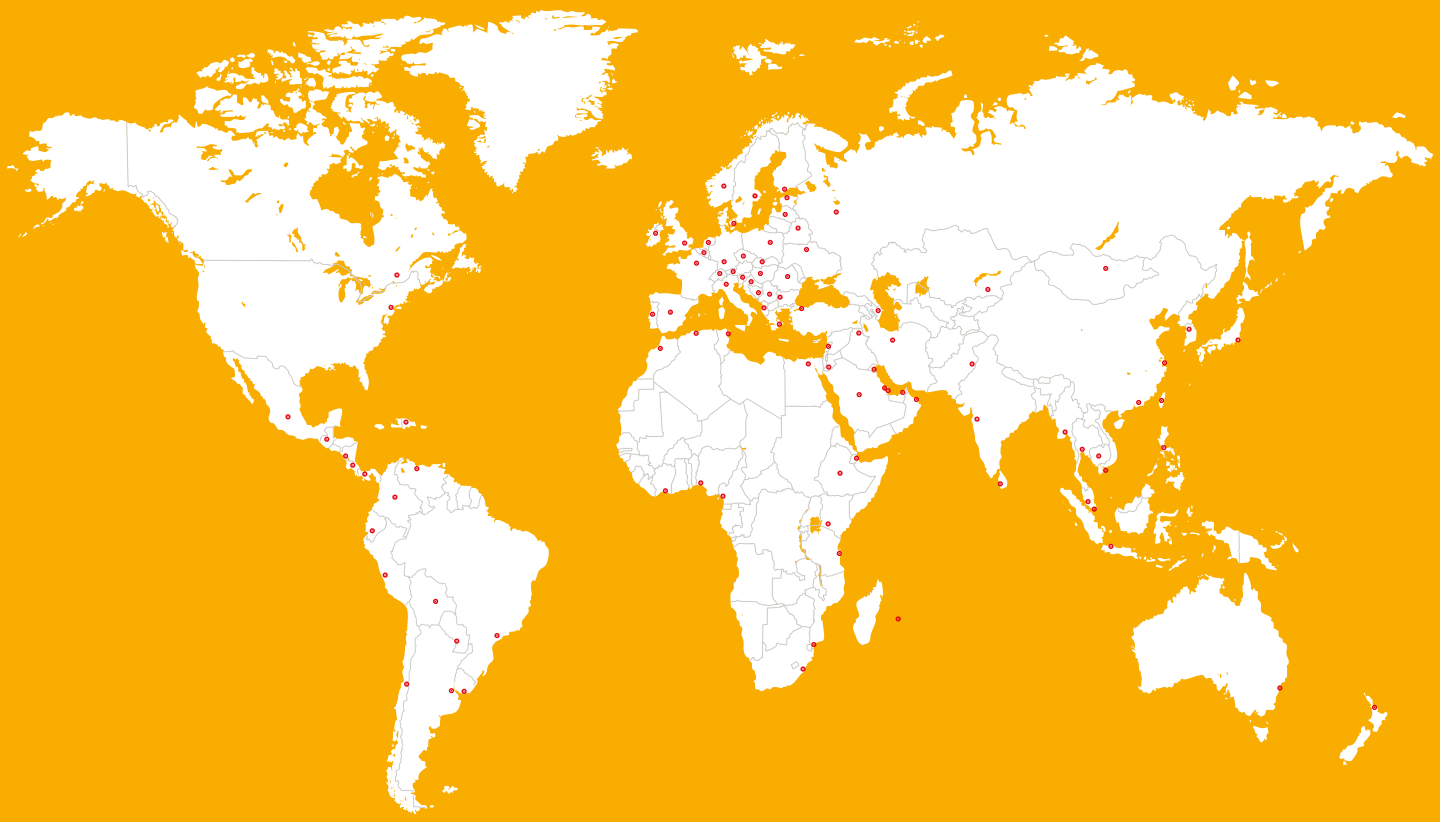
REQUIREMENTS

The main requirement for his project was a heavyweight concrete with a density of minimum 3'200 kg/m^3. To fulfill this requirement the concrete plant used magnetite aggregates, a very heavy, ferrous material from Northern Sweden named "MagnaDense". The density of these aggregates is higher than 4'700 kg/m^3. Heavyweight concrete requires also special attention on practical level. Furthermore heavyweight concrete is always a challenge regarding the workability and pumpability. The concrete has to have the right consistency in order to be easily pumpable and to avoid segregation of the heavyweight aggregates.

Sika® ViscoCrete® SOLUTION

Without an admixture like plasticizer or superplasticizer the concrete wasn't flowable enough to fulfill above mentioned requirements. Therefore the concrete producer turned to Sika to improve and maintain improved consistency of the heavyweight concrete.
Sika has tested the mix design with a superplasticizer of the 3rd generation: Sika® ViscoCrete ® 2420 con. 20%. For further optimization Sika designed a mix-design for the heavyweight concrete and determined the right dosage of admixture which on the one hand allowed the concrete to be pumped and on the other hand to maintain a stable mix without the use of any stabilizer.

GLOBAL BUT LOCAL PARTNERSHIP



FOR MORE INFORMATION:

Who we are
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.

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