CEMENT ADDITIVES
FINEST STRENGTH DEVELOPMENT

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SIKA ADDS VALUE TO YOUR CEMENT

Cement is vital for today's construction industry. The cost optimized production of quality cement which meets customer demands and standards as well as sustainability issues challenges every cement plant individually. Sika offers innovative cement additive concepts combined with a specialized technical support, targeting improved production rates, enhanced strength development and adjusted workability. The reduced utilization of energy and clinker contributes to the profitability of your business.

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Finest strength development

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Cement is a key success factor within today's construction challenges and frequently the solution for the difficult task of increasing economy while preserving nature. Despite continuous optimisations towards more efficient and environmentally-friendly production methods, cement production still leaves a footprint in the environment. Sika AG offers strength enhancing solutions which allow for cost-effective and ecologically-friendly clinker reduction.

Apart from the emissions associated with the consumption of thermal and electrical energy, the natural release of CO_2 resulting from the calcination process during clinker production is unavoidable[1]. The substitution of clinker with secondary cementitious materials (SCM) like granulated blast furnace slag, fly ash, natural pozzolans and limestone reduces the carbon dioxide emission per tonne of cement and saves raw material costs. The main difficulty with blended cements is slower strength development compared to pure Portland cements at constant fineness. This gets more pronounced with an increasing amount of clinker replacements and can also imply reduced final strength.

The concept of achieving the highest amounts of secondary cementitious materials is linked to:

- locally available materials and their characteristics
- conditions during the cement grinding process
- strength demands by standards and customers.

This requires creating individual solutions for each cement plant or even for single cements.

How to improve strength?

There are several ways to generate the desired strength development and strength potential of cement. The impact of major options and the role of modern cement additive technology therein are described in the two following sections:

- Improved cement fineness with adjusted separator setting and grinding aids, expressed as:

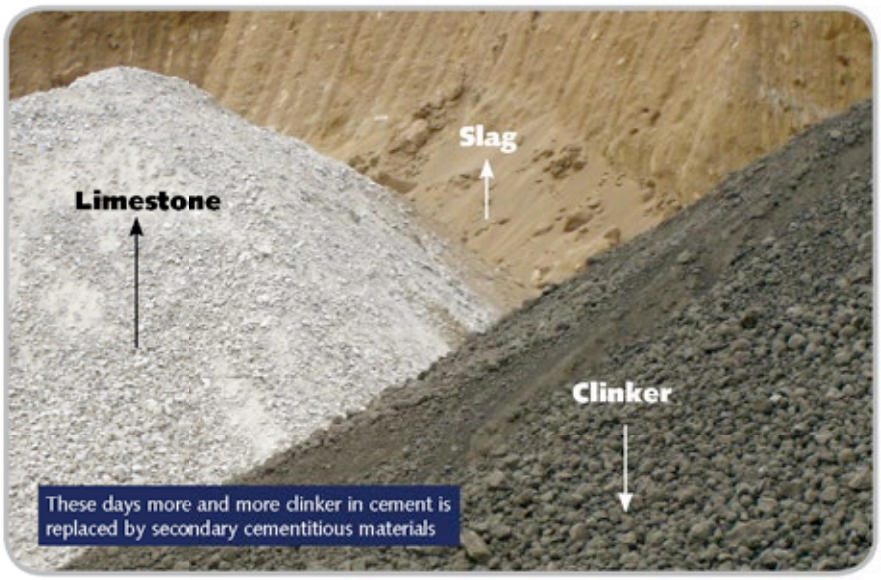
a) higher specific surface according to Blaine

b) optimised particle size distribution of the cement, targeting the particle fraction 3-32µm.

- Chemical activation of the hydration process with cement additives, to achieve enhanced

a) early strength

b) final strength.

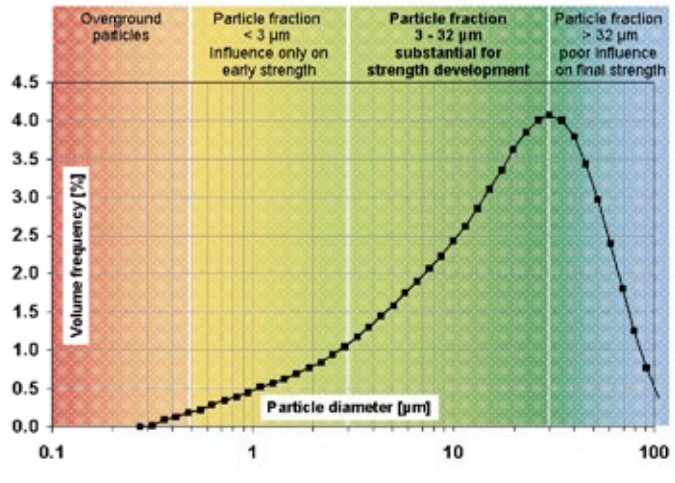


These days more and more clinker in cement is replaced by secondary cementitious materials

Improved cement fineness

The positive influence of higher fineness on the strength development and strength potential is well-known. For example, it is the main criterion to adjust the different strength classes of pure Portland cement. In blended cement,

Figure 1: importance of different particle fractions in cement particle size distribution



fineness and composition of the cement affect each other, which makes it more challenging to find the optimum setting for both parameters.

During the attempt to increase the amount of clinker replacements, higher fineness is usually disregarded, since this would reduce the cement production rate by approximately 3-4 per cent per 100cm²/g specific surface and hence lead to a higher specific energy consumption[2]. Grinding aids help to achieve the desired fineness at the most economic way while compensating at least partially this loss of production rate. Polycarboxylate polymer (PCE)-powered grinding aid technology causes a stronger production increase compared to traditional grinding aids based on amino alcohols or glycols[3]. This additional grinding and separating efficiency can be used to achieve higher cement fineness at constant production parameters.

Optimised particle size distribution

Most commonly, the fineness is expressed as specific surface according to Blaine. The larger the Blaine value, the faster is the strength development and the higher is the strength potential. More accurate information about the fineness of cement can be drawn from the particle size distribution (PSD) (see Figure 1), which is usually measured with the laser diffraction method. It can be characterised according to the RRSB method by means of the position parameter 'x' (smaller value = bigger proportion of fine particles) and the slope 'n' (bigger value = narrower distribution). At equal specific surface, an optimised particle size distribution would result in a greater proportion of the particle size fraction 3-32µm which is the most important for the strength development[4].

At constant production parameters and dosage like the traditional amino alcohol-based grinding aid, the polycarboxylate polymer powered grinding aid achieved in the following plant trial example (see Figures 2a, 2b and Table 1) a narrower particle size distribution and a smaller position parameter. A substantial strength increase at all ages which allows reducing clinker content was the consequence of the increased particles size fraction 3-32µm.

Decreasing the carbon footprint and

Figure 2a (and 2b below): improvements at all stages of strength development due to an optimised particle size distribution using the polycarboxylate polymer-powered grinding aid

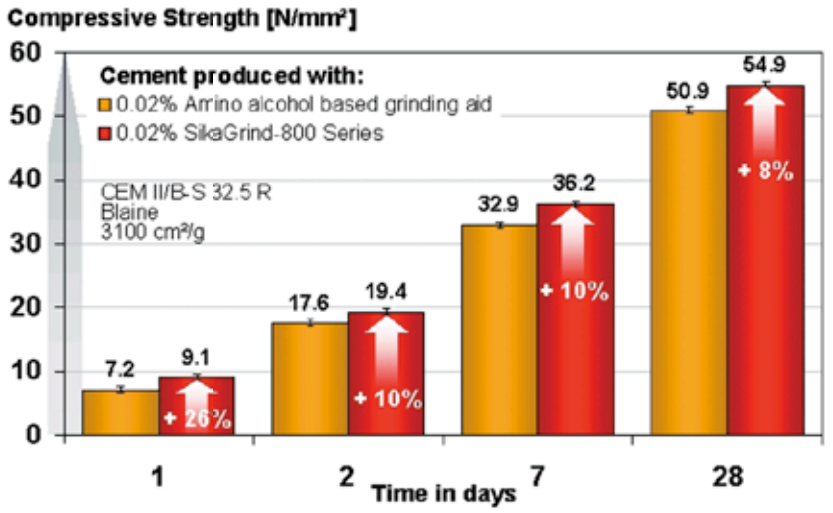


Figure 2b

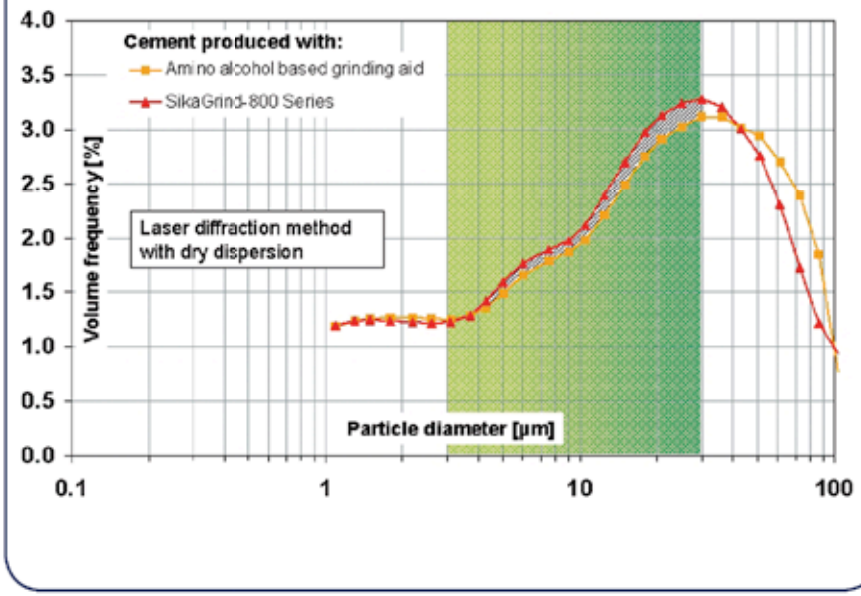


Table 1: comparison between an amino alcohol-based grinding aid and SikaGrind 800 Series grinding aid

CEM II/B-S 32.5R	*Amino alcohol-based grinding aid*	*SikaGrind-800 Series grinding aid*
Production (tph)	70	71
Dosage (%)	0.02	0.02
Blaine (cm²/g)	3090	3125
Sieve residue 32µm (%)	31.5	24.9
Inclination 'n' in RRSB diagram	0.80	0.83
Position parameter 'x' in RRSB diagram (µm)	21.5	19.8
Water demand (%)	26.8	26.4

increasing the cement manufacturer's profitability can be achieved with enhanced quality resulting from an optimised fineness at constant production.

Chemical activation

One of the most desired effects of cement grinding aids with performance enhancing characteristics, so-called quality improvers, is to accelerate cement hydration and thus strength development. Various amino alcohols but also other raw materials are commonly used to address different stages of the strength development.

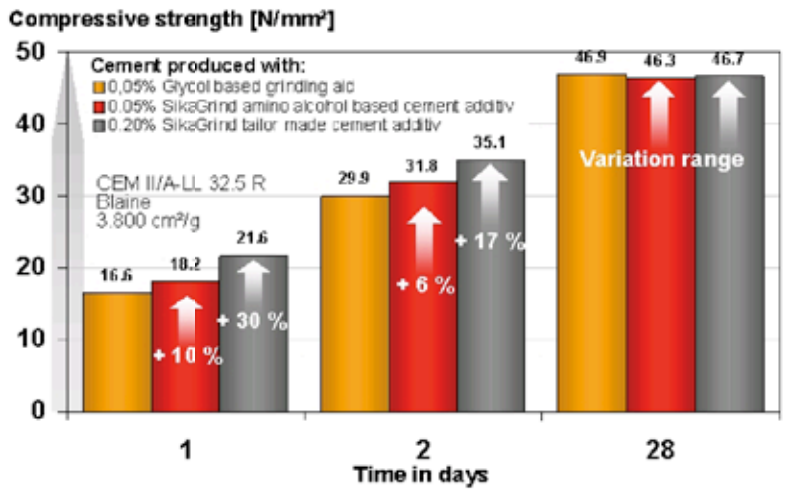
Glycol-based grinding aids, however, are usually known to be inactive regarding a chemical activation of hydration. Sika offers standard as well as tailor-made products with the aim to improve the strength development, using several techniques of chemical activation. In most cases, these quality improvers can be combined with traditional grinding aids as well as with the new polycarboxylate polymer powered grinding aid technology.

Early strength enhancement

Figure 3 shows a considerable early strength increase of two SikaGrind early strength enhancers versus a glycol based grinding aid. The fineness according to Blaine as well as the particle size distributions of these limestone cements tested in laboratory trials was constant.

The standard amino alcohol-based cement additive gains approximately 2N/mm² more strength after two days. The tailor-made product which was modulated to the existing conditions results in a more pronounced strength increase of up to 5N/mm² after one and two days. Final strength, in contrast, is affected only slightly by pure early-strength enhancers. The achieved advantages can be used to raise the proportion of clinker replacements or partially use less reactive clinker.

Figure 3: early strength enhancement with SikaGrind technologies versus a pure glycol based grinding aid



Chloride-enhanced early strength activation

Chlorides surely belong to the most efficient and less sensitive early-strength enhancers. Due to the utilisation of chloride containing secondary fuels or the application of kiln dusts as cement constituent, the chloride content in today's cements is frequently close to the limit and permits only a small dosage of chloride powered early strength enhancer.

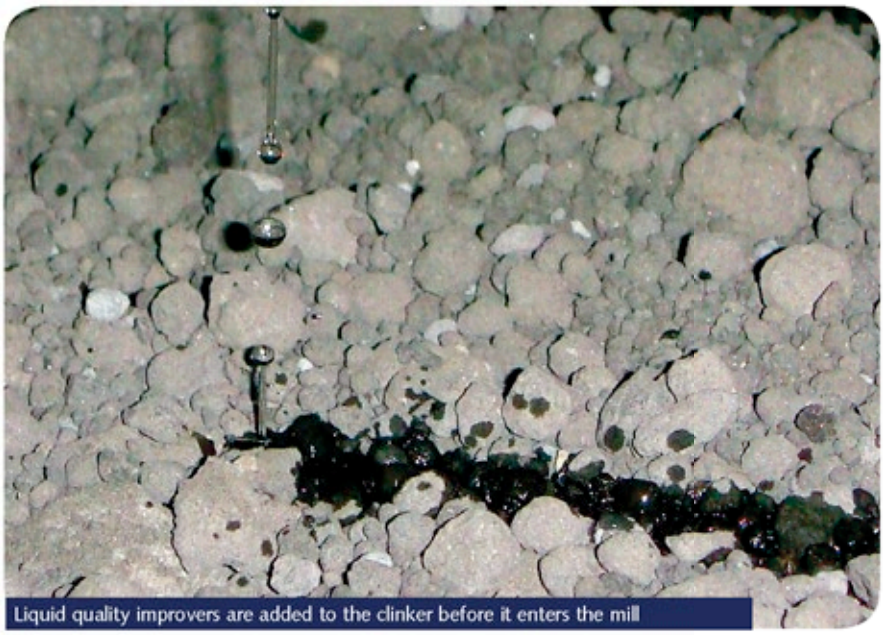
Nevertheless, to create environmentally friendly cements with highest amounts of clinker replacement which fulfil the strength demands of standards and the construction industry, this potential should not be rejected in general. Sika offers the possibility to create tailor-made products which incorporate the local conditions and ensure that the restrictions, eg the limit for the chloride content in the cement are kept.

Final strength enhancement

Improved final strength is of highest interest for cements with a high amount of limestone as clinker replacement. In times when frequently-used secondary cementitious materials like blast furnace slag suffer a shortage, raw materials like limestone which can be extracted from cement producers own quarries gain higher importance.

It is well known that at constant fineness the strength of cements with interground limestone decreases by an amount related to the magnitude of limestone used[5]. Thus, blended cements or at least the clinker component thereof must be ground considerably finer to gain the same strength level like pure Portland cement. This leads to a loss of production rate.

The following plant trial example addresses these topics. Figure 4a, 4b and Table 2 show a distinct increase of final strength using SikaGrind strength enhancer versus the presently used traditional glycol-based grinding aid.



Liquid quality improvers are added to the clinker before it enters the mill

This strength enhancement must be entirely based on chemical cement hydration activation since the particle size distributions of both cements are comparable which is confirmed by all measured parameters. This specific product offers another advantage which is associated with the use of polycarboxylate polymer powered grinding aid technology as basis of this final strength enhancer. As a result, an additional five per cent production increase versus the already strong production values with the established grinding aid was achieved.

Conclusions

The pressure to reduce CO_2 emissions demands increasing amounts of clinker replacements in cement formulations. This implies a loss of strength and production capacity which needs to be compensated.

Sika supplies customised cement additives to adapt the strength development to individual demands. The proposed solution considers the required fineness and production parameters. Besides combinations of chemically-activated early and final strength, improved cement fineness towards an optimised particle size distribution is another reasonable alternative to achieve bigger shares of secondary cementitous materials or partially use less reactive clinker. A potential loss of production rate can be compensated by the more efficient polycarboxylate polymer powered grinding aid technology of the SikaGrind-800 series, which also can be incorporated into quality improvers targeting early and/or final strength via chemical activation.

SikaGrind products support finest strength development of cement, enabling cement manufacturers to decrease the carbon footprint and maximise their profitability as well.

References

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3. SCHRABBACK, J M, "Polycarboxylate polymer-powered grinding efficiency", *GCL*, July-August 2009, pp14-16.
4. TSIVILIS S, TSIMAS S, BENETATOU A and HANIOTAKIS E, "Study on the contribution of the fineness on cement strength", *Zement-Kalk-Gips*, January 1990, pp26-29.
5. ELLERBROCK, H-G, SPRUNG S and KUHLMANN, K, "Influence of interground additives on the properties of cement", *Zement-Kalk-Gips*, October 1985, pp586-588.

Figure 4 (and 4b below): final strength enhancement due to chemical hydration activation with SikaGrind-800 technology versus a pure glycol-based grinding aid

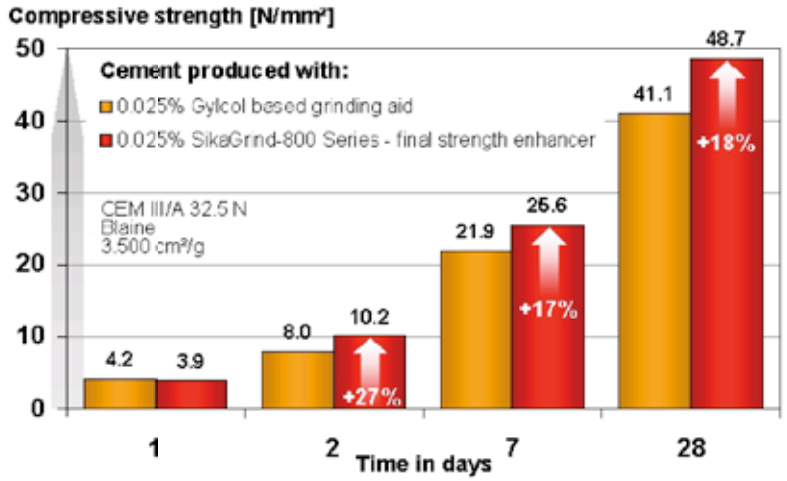


Figure 4b

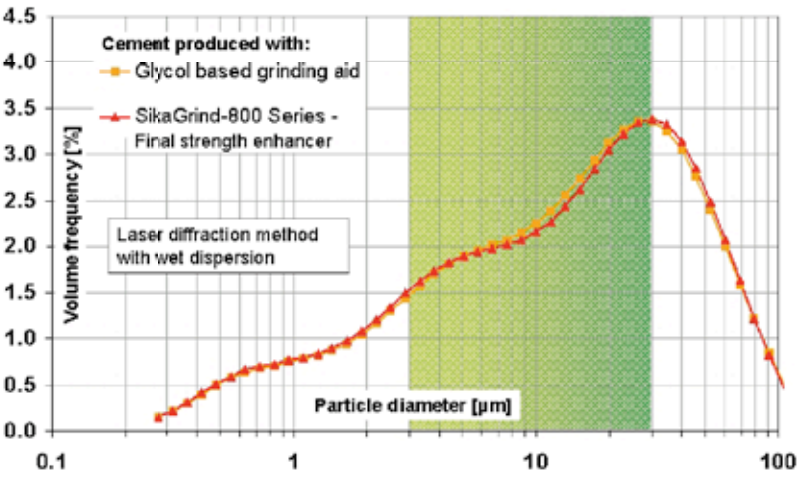
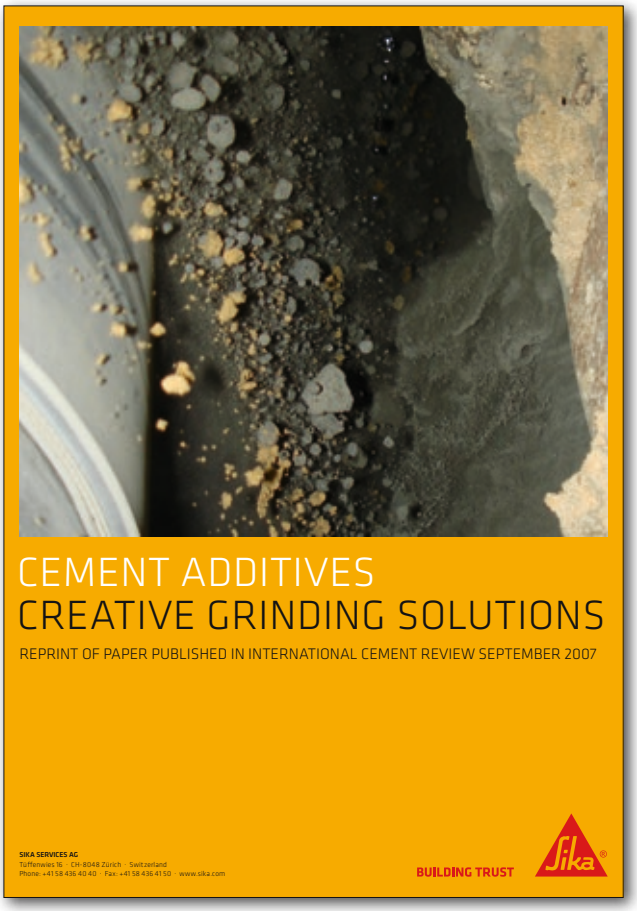
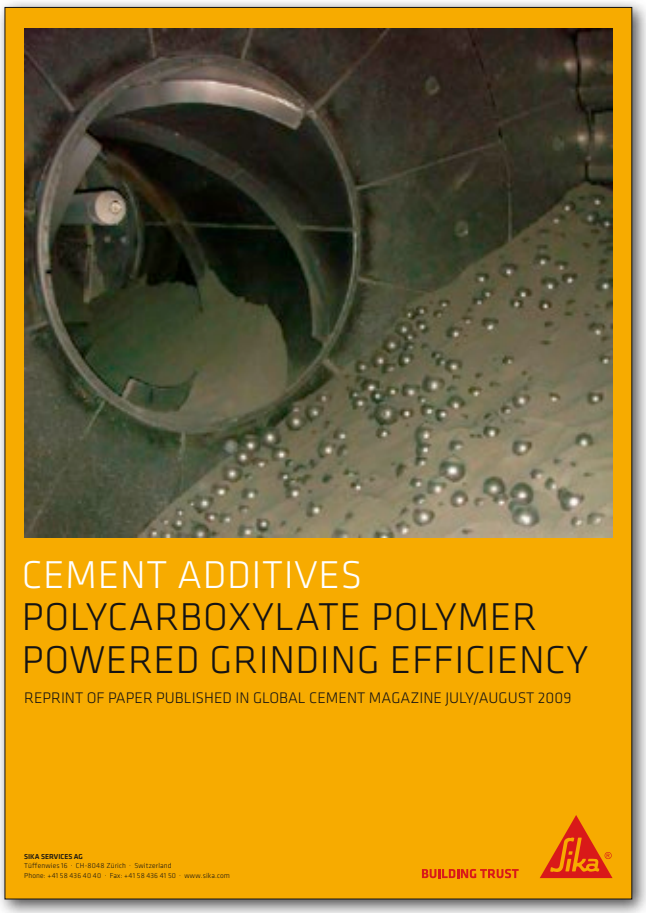


Table 2: comparison between a glycol-based grinding aid and a SikaGrind-800 Series final strength enhancer

CEM III/A 32.5N	*Glycol based grinding aid*	*SikaGrind- 800 Series final strength enhancer*
Production (tph)	109	114
Dosage (%)	0.025	0.025
Blaine (cm^2/g)	3535	3550
Sieve residue 3µm (%)	14.5	14.1
Inclination n in RRSB diagram	1.02	1.02
Position parameter x in RRSB diagram (µm)	21.6	21.1
Water demand (%)	28.0	27.7

Also Available:





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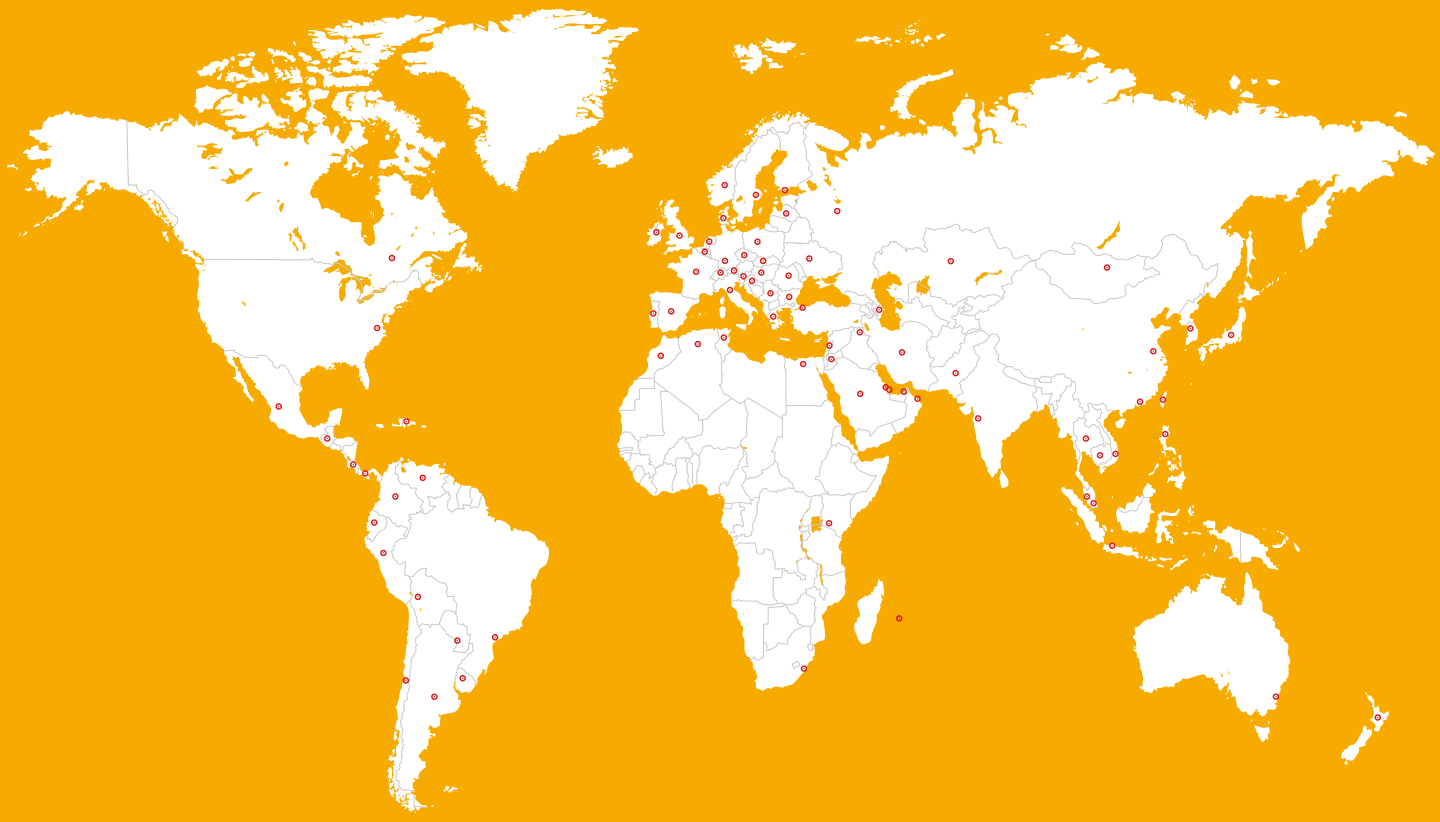

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Sika AG, Switzerland, is a globally active specialty chemicals company. Sika supplies the building and construction industry as well as manufacturing industries (automotive, bus, truck, rail, solar and wind power plants, façades). Sika is a leader in processing materials used in sealing, bonding, damping, reinforcing and protecting loadbearing structures. Sika's product lines feature highquality concrete admixtures, specialty mortars, sealants and adhesives, damping and reinforcing materials, structural strengthening systems, industrial flooring as well as roofing and waterproofing systems.

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