KAOROCK™

Thiele

Engineered metakaolin for concrete

Test- and Field-Proven Benefits of KAOROCK™

- Significant increases in compressive and flexural strength, especially early age strengths
- Enhanced concrete durability
- Reduction or elimination of ASR and efflorescence
- Reduced permeability
- Enhanced resistance to chemical attack
- Improved handling and color matching

Unlike silica fume and fly ash, KAOROCK™ is white improving appearance in decorative and architectural concrete structures.

KAOROCK™ is a metakaolin that enhances the properties of concrete and cement-based products. It is an ultra-fine material that is white in color produced from kaolin, an aluminum silicate mineral mined in middle-Georgia. Because KAOROCK™ is not a by-product as other pozzolans on the market such as silica fume and fly ash, product quality and specifications can be strictly controlled from batch to batch.

Applications with KAOROCK™

KAOROCK™ can be used in many different applications. It can be used to replace a portion of Portland cement in concrete formulations or as an additive.

Architectural Concrete—Since KAOROCK™ is white, it will not darken the appearance of concrete. In fact, it improves the consistency of color in your concrete because the color of KAOROCK™ will always be the same. When appearance is important, as with certain precast concrete structures such as countertops and floors, KAOROCK™ is the perfect choice.

This foundation uses split block that has KAOROCK™ in the formulation for added strength and durability with excellent visual appearance.

High Performance Concrete (HPC)—
KAOROCK™ has been found to meet or exceed the benefits of silica fume. It significantly increases both flexural and compressive strength, while at the same time improves the durability of the finished structure. Specifically, KAOROCK™ is an excellent candidate for:

- Marine environments—bridges, dams and piers
- Public roads—Fast-track paving
- Concrete structures—parking areas, garages, buildings
- Precast concrete applications

Using pozzolans such as KAOROCK™ can extend the life of structures that demand a high performance concrete.

Thiele Kaolin Company, PO Box 1056, Sandersville, GA 31082 Phone: 877-544-3322 Fax: 478-552-3951 thielekaolin.com

Swimming Pools—KAOROCK™ produces formulations that are very easy to handle during application and during finishing. In addition, the particle structure of KAOROCK™ reduces permeability and eliminates efflorescence making it more durable in the chemical environment of pools.

Being white in color with long-lasting durability, KAOROCK™ is an excellent plaster additive in improving the final appearance of swimming pools.

KAOROCK™ Benefits Concrete

Increased Compressive strength—KAOROCK™ increases strength in all stages of the curing process. It reacts with the free calcium hydroxide (lime) produced during the cement hydration process to form additional cementitious material (see Figure 1).

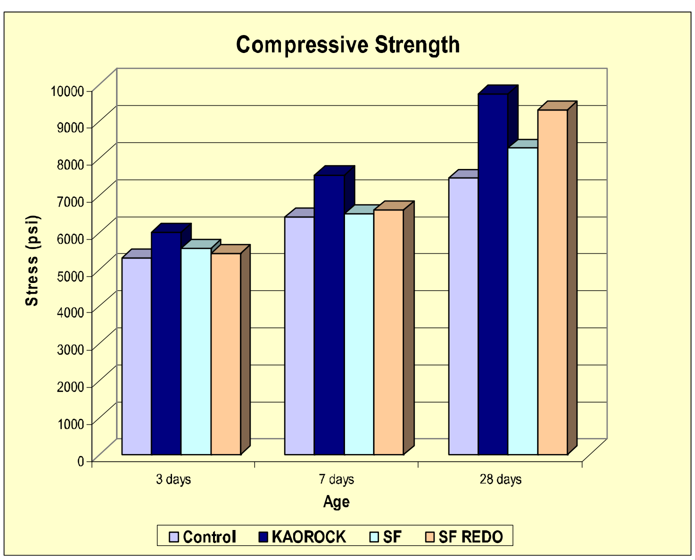

Figure 1: Both KAOROCK™ and silica fume showed increased strength in this laboratory test. Preliminary data on silica fume showed indicated a decrease at 1-day strength. As a result, a new silica fume sample was acquired and the test repeated.

Increased Flexural Strength—KAOROCK™ increases flexural strength during the curing process, especially at early stages. During testing, concrete prisms were subjected to four-point bending with a water to cement ratio of 0.4 (see Figure 2). In looking at the results, metakaolin and silica fume reached 600 psi in one day indicating relevance to pavements. Metakaolin could be used to shorten the time needed before newly paved roads may be opened to traffic.

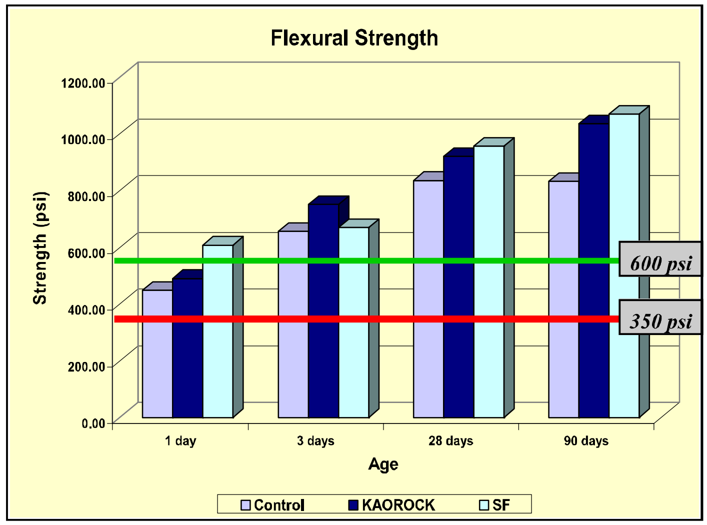

Figure 2: Average peak flexural strength (modulus of rupture) versus concrete age for w/cm of 0.40.

Reduction or Elimination of Efflorescence—Water enters the masonry structure through absorption and through cracks and joints. This water dissolves the available calcium hydroxide (lime) that is produced during cement hydration. This water migrates to the surface and evaporates leaving behind the lime, which can show up as a crystalline or powdery, unattractive deposit. KAOROCK™ helps to eliminate this effect by reacting with the free lime to form additional cement and by lowering the permeability of the structure; thereby, making it more difficult for water to move to the surface.

This is an example of a concrete slab with efflorescence. KAOROCK™ helps to eliminate this in concrete structures.

Reduction or Elimination of Alkali-Silica Reactivity (ASR)—Silica is present in concrete due to the cement hydration process, and will react with the different aggregates found in concrete. As a result, this silica can dissolve and produce a gel. When moisture is present, the gel expands and results in stresses on the structure which can lead to cracks in the concrete. KAOROCK™, with its structure and reactivity, greatly reduces ASR. Since it reacts with lime, KAOROCK™ lowers the alkalinity of concrete, decreasing the reactivity of the silica (see Figure 3).

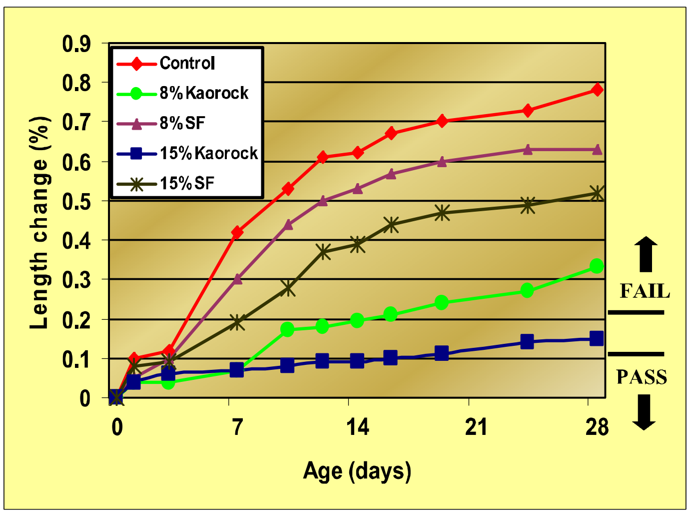

Figure 3: Expansion due to alkali-silica reacation, w/cm = 0.47, was measured according to the accelerated mortar bar method (ASTM C 1260). This method has proven reliable for evaluating the effectiveness of SCM's in suppressing ASR. KAOROCK™ passed while the control and samples made with silica fume failed.

Reduced Permeability—Due to its particle shape and size, KAOROCK™ can greatly reduce the permeability of a concrete mix. It is very effective in reducing chloride ion ingress, with values in the low or very low (below 2000 Coulombs) range.

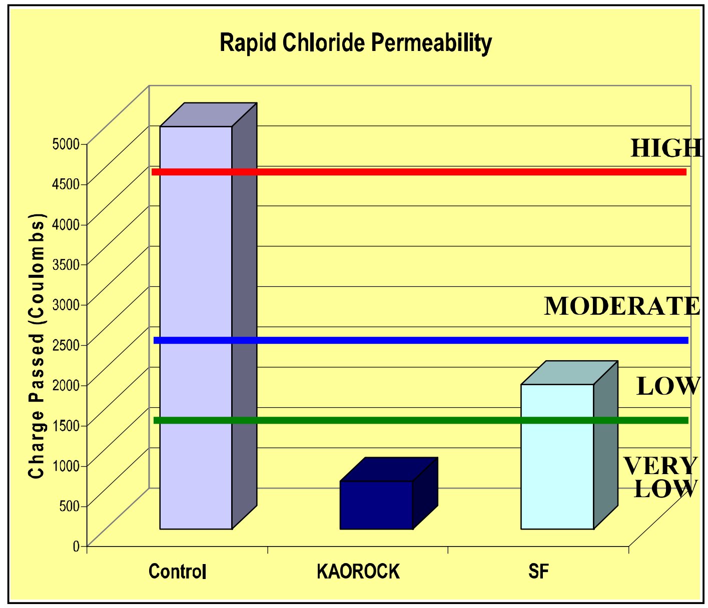

Figure 4: Experimental test data on rapid chloride permeability shows KAOROCK™ with a remarkably lower permeability than the control and silica fume.

KAOROCK™ in use at Thiele Kaolin Company

Concrete without pozzolans can deteriorate faster than expected due to poor chemical resistance and permeability issues. This frame was repaired with a concrete mix that included KAOROCK™.

This concrete from a ditch at a kaolin processing plant was in need of repair due excessive corrosion. KAOROCK™ was added to the repair concrete mix for added durability.

KAOROCK™—*Engineered metakaolin for concrete* Thiele

KAOROCK™—An In-Depth Look

What is an engineered metakaolin?
Metakaolin differs from other supplementary cementitious materials like fly ash, slag or silica fume, in that it is a not a by-product of an industrial process; it is manufactured for specific purpose under controlled conditions. Metakaolin is produced by heating kaolin, a natural clay that is in abundance in middle-Georgia, to temperatures between 1200-1750°F (650-900°C). This treatment, called calcination, radically modifies the particle structure making it a highly reactive, amorphous pozzolan.

How does KAOROCK™ work?
During the cement hydration process, water reacts with Portland cement to form calcium-silicate-hydrate (CSH). A by-product of this reaction is the formation of calcium hydroxide, or lime. This lime is the weak link in concrete, and it reduces the effect of the CSH. When KAOROCK™ is present in the hydration process, it reacts with the free lime to form additional CSH material, thereby making the concrete stronger and more durable (see equations below).

Portland Cement + Water = Cementitious Materials + Lime

Lime + KAOROCK™ = Additional Cementitous Materials

A recent, independent laboratory study of mortar pastes demonstrates the ability for KAOROCK™ to react with the free lime at early stages in the curing process (See Figure 'a' below). For the control, pastes were made without any pozzolanic material, and then KAOROCK™ and silica fume replaced a portion of the Portland cement (8% and 15%). The pastes containing KAOROCK™ showed higher heats of evolution than the control mix or silica fume.

Silica fume reduced both the rate of heat evolution and the total heat evolved, likely due to the removal of cement from the system. Further, silica fume rate curves follow the same general profile as the control, with the first peak, corresponding to the CSH hydration, reaching higher than the second peak (C_3A). This reflects dilution of the cement hydration and indicates that there is little secondary reaction occurring at these early ages.

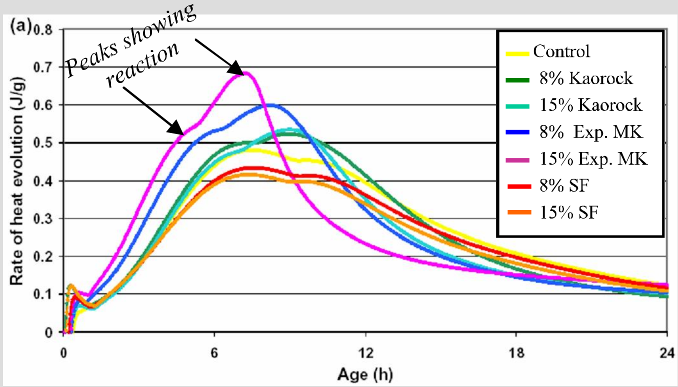

Figure 'a': Isothermal calorimetry showing rate of heat evolution

The KAOROCK™ curves show the opposite trend: the second peak is higher than the first, likely indicating the pozzolanic reaction of metakaolin. These results illustrate that metakaolin is highly reactive at very early ages.

KAOROCK™ Typical Properties

Particle Size	
Median particle size (microns)	1.5
Finer than 2 microns, %	65
Fineness	
% retained, 325 mesh	0.1
Bulk Density	
Loose (lbs/ft^3)	18
G.E. Brightness	
Dry, % minimum	80
Surface Area	
M^2/g	11
Loss on Ignition	
%	0.5

<u>DISCLAIMER</u>: Sales are made with the understanding that purchasers will determine the suitability of products for their particular purposes and Thiele makes no warranty for a particular purpose. No warranty of merchantability, nor other warranty, express or implied, is made. Similarly, Thiele Kaolin Company cannot assume responsibility for risks or liabilities, direct, indirect, or consequential, which may result from the use of its products. Likewise, no liability is assumed for any claimed patent infringement occurring by reason of any method of use of the customer.

Thank you for your interest in Thiele Kaolin products. For additional information on our company, KAOROCK™, including MSDS sheets, laboratory test results or a product sample, please contact us today.

Thiele Kaolin Company
PO Box 1056
Sandersville, GA 31082

Internet: www.thielekaolin.com

Thiele
Tailoring kaolin to your needs

Phone: 877-544-3322
478-552-3951
Fax: 478-552-4131

E-mail: kaorock@thielekaolin.com