

METAKAOLIN

A Highly Reactive Natural Pozzolan

CONFIDENTIAL – BURGESS PIGMENT CO. 2023
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Overview



Fish River Bridge in Florida.
Concrete has 12% metakaolin.

- What is Metakaolin
- Origins of kaolin
 - Kaolin Industry
- Processing
 - Calcination
- Pozzolanic Reactivity
- Benefits & test results
- Application areas

What is Metakaolin (MK)?

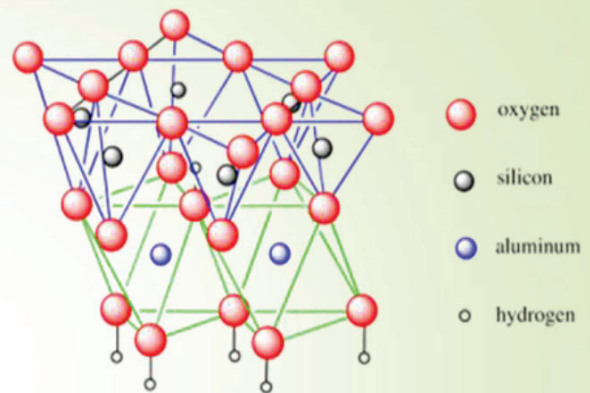
- It is an aluminum silicate
- Pozzolan (Natural Pozzolan)
 - Pozzolans convert free lime into cementitious binder.
- Calcined Kaolin Clay
- Supplementary Cementitious Material

ASTM definition of a Pozzolan.

A pozzolan is a siliceous or siliceous and aluminous material that possesses little or no cementitious value but will, in finely divided form and in the presence of moisture, chemically react with calcium hydroxide at ordinary temperatures to form compounds having cementitious properties.

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Geology & Geography



Kaolin:
38% Alumina,
46% Silica,
14% Structural water &
minor amounts of other oxides.

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Kaolin Mining in Middle Georgia



This open pit mine is just off the Fall Line Freeway between Sandersville and Milledgeville.

The Numbers:

- WW – 23 M tons of Kaolin
- USA – 8 M tons of Kaolin
- Georgia – 6.5 M tons
- Cement used <5% of kaolin in 2006. (<1M tons)

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Metakaolin - Processing

- ▶ Water washed kaolin clay
 - ▶ Removes non-reactive impurities
 - ▶ Finer particle size with enhanced reactivity: <math><2\mu</math>
 - ▶ Whiter product
- ▶ Air-float kaolin clay
 - ▶ Removes fewer impurities – less reactive product.
 - ▶ Coarser product: >3 μ
 - ▶ Darker colored product



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Metakaolin - Calcination

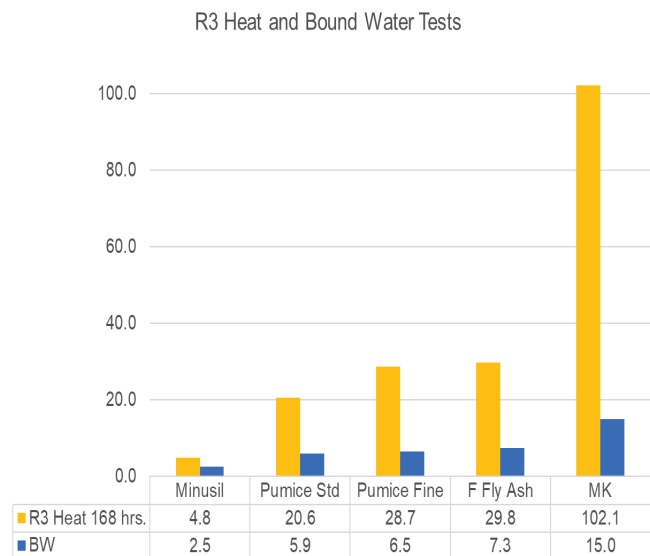
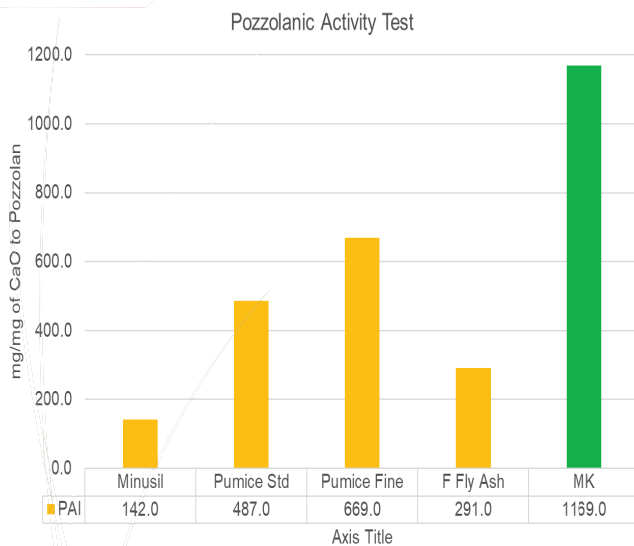
- Conventional calcination
 - Slightly less reactive
 - Lower color
 - Higher specific gravity; 2.6
- Flash calcination
 - Slightly more reactive
 - lower specific gravity; 2.2
 - More particles per unit weight
 - Brighter color appearance



The time/temperature profile must maximize the amorphous phase.



Pozzolanic Reactivity



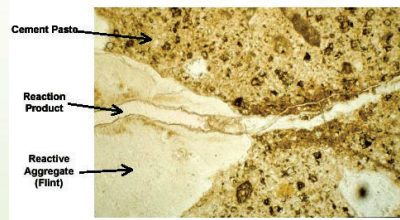
There are activity programs designed to determine the activity of pozzolanic and hydraulic materials. This data shows excellent correlation between several of these tests. The Pozzolanic Activity Test is designed to prove if “pozzolanic” materials meet the definition of pozzolan as stated by ASTM.

**R3 Heat Data provided by Dr. Maria Juenger at UT Austin.
Bound Water data provide by Dr. Mike Thomas at UNB.**



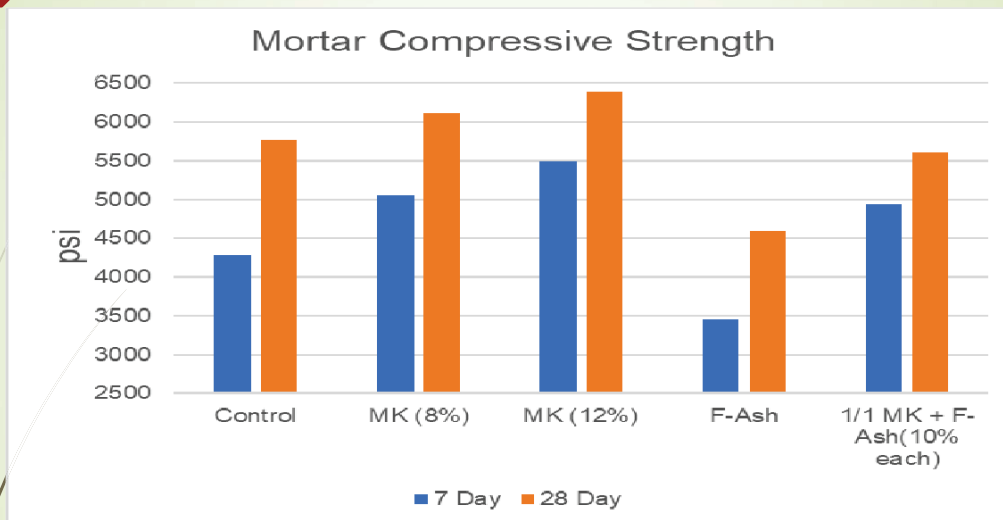
Metakaolin Test Results

- Improves Compressive Strength
- Improves Flexural Strength
- Reduces Rapid Chloride Permeability
- ASR mitigation
- Reduction in Efflorescence
- Increases expected service life



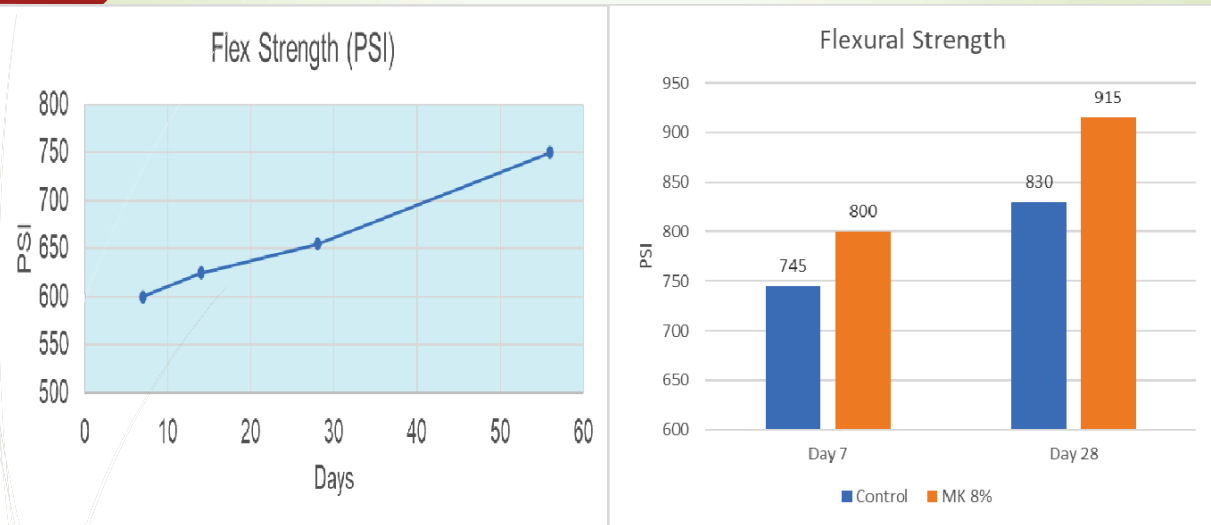
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Metakaolin Blend w/ F-ash Compressive Strength



In a mortar mix, the metakaolin alone shows compressive strength improvement over the control and well above the fly ash at 20% loading. A blend of metakaolin with the f-ash shows that the blend is now equivalent to the control.

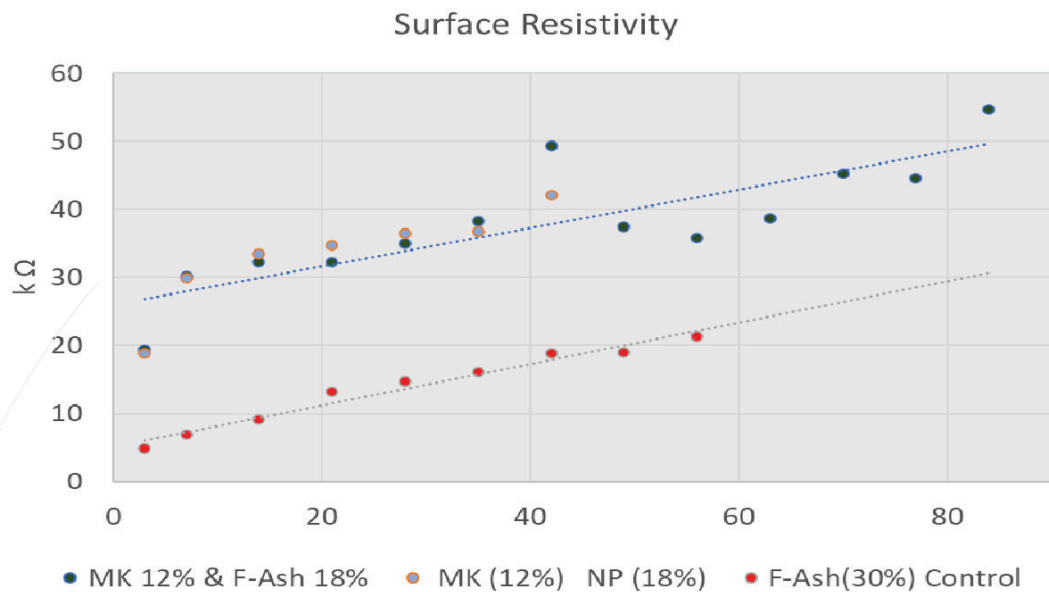
Flexural Strength



In the two studies above MK demonstrates good increases in flexural strength development over time. Furthermore, the study on the right shows greater strength than control. The study on the left, done for the MnRoad project, shows the MK formulation well above the cut-off limit of 500psi.

Data generated by Braun Intertec for MnRoad Project.

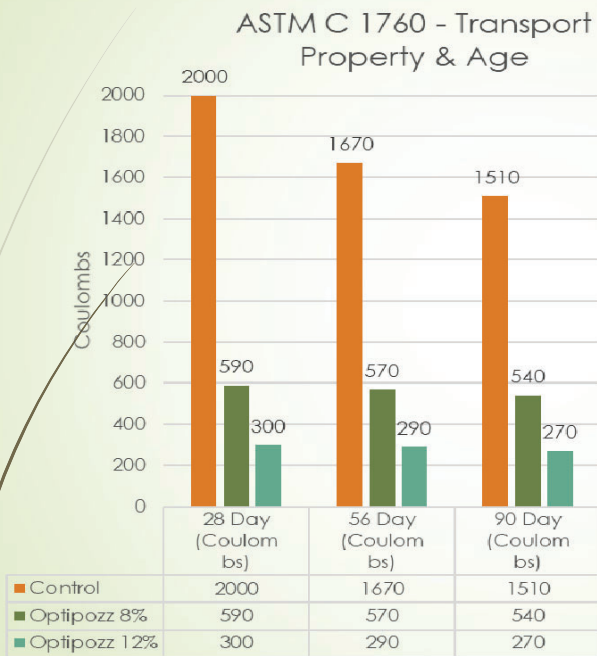
Surface Resistivity



Surface resistivity measurements demonstrate that MK blends perform better than straight F Ash. This is due to the rapid reaction of the MK with the free lime.

Data generated by John Edwards @ 3M complete data set to be presented at NPA Symposium

Transport Properties – C1760



This test measures the bulk conductivity of the specimen and can be related to the apparent chloride diffusion coefficient in test, ASTM C1556.

Metakaolins, by reacting with the free Ca(OH)_2 and filling the pores with cementitious material a less permeable concrete is formed, thereby allowing less ingress of ions and water.

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Reduction in Efflorescence



Efflorescence is virtually eliminated when a metakaolin is used at sufficient loading levels to react with the free lime, Ca(OH)_2 .

Stadium® & Life 365™ Results

Miami Tidal Pile

Life 365™	Control	METAKAOLIN 8%	METAKAOLIN 12%
Projected Service Life (Years)	13	38	58
STADIUM®	Control	METAKAOLIN 8%	METAKAOLIN 12%
Projected Service Life (Years)	14	37	59

Computer modeling demonstrates that the use of metakaolin can extend the service life of concrete in harsh environments. This makes metakaolin a cost-effective option when evaluating total lifecycle costs.

Detroit Bridge Deck

Life 365™	Control	METAKAOLIN 8%	METAKAOLIN 12%
Projected Service Life (Years)	34	95	109
STADIUM®	Control	METAKAOLIN 8%	METAKAOLIN 12%
Projected Service Life (Years)	26	85	>100

Summary

- Metakaolins are Pozzolanic, Supplementary Cementitious Materials that deliver very high pozzolanic activity.
- Metakaolins are typically used at levels between 8% to 12% replacement of cement.
- The use of metakaolins can increase the expected life of concrete in harsh environments.
- Metakaolins create stronger concrete, less porous concrete.
- Can be used with class f-ash or other natural pozzolans.

NPA Symposium



- Wickenburg, Arizona - May 16 – May 18, 2023
 - Rancho de los Caballeros Resort
- Natural Pozzolans Papers covering many technical topics.
 - Water Demand of NPs
 - NPs in Ready Mix Concrete
 - NP in 1L Concrete with Flexural and Surface Resistivity Data
- Visit NPA.org (Natural Pozzolan Association)

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THANK YOU!



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