Relationship between Strength Development and Pozzolanic Reactions in Lime Stabilized Kaolinite

Tasneem Ahmadullah, Marisa Chrysochoou, PhD

Civil & Environmental Engineering Department, University of Connecticut

Problem

Clay swelling damages in pavement = $1 billion costs annually

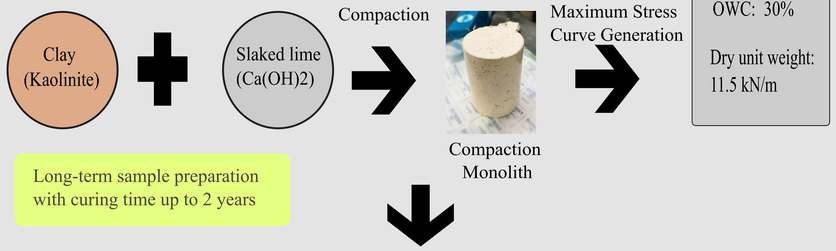
Treatment

How do clay properties affect reaction?

How does lime react over time?

How does strength increase over time and why?

Methodology



Unconfined Compressive strength test

Broken Sample

Core of the sample

Squeezing apparatus

Post curing samples processing :

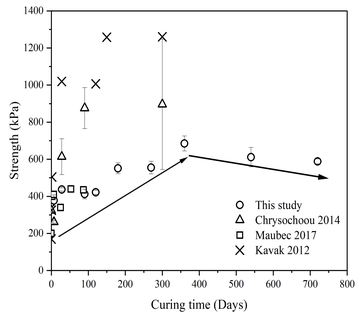
1. Strength test (Unconfined Compressive Strength test)
2. Squeezing of broken chunks for liquid test, using custom-made squeezing apparatus.
3. Drying of solid chunks for solid test, acetone drying for NMR, IPA drying for XRD & TGA.

Acknowledgement

National Science Foundation (NSF).Project No- 1740554

Data Synthesis

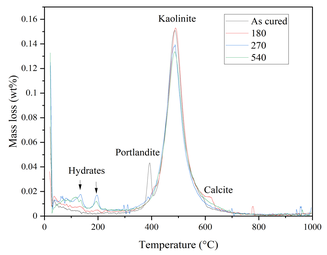
Strength data analysis



Strength is increasing linearly over time up to 1 year followed by a 14% decrease in the second year.
Physical properties (particle size and dry unit weight cause differences in strength.
It is also evident from the data that the industrial standard 28 days is not enough to see the stregth behavior of kaolinite.

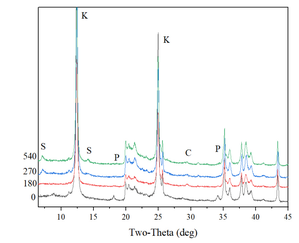
Qualitative Analysis of Clay-Lime Reaction

TGA



1. Two separate hydration products are formed over time.
2. Portlandite is consumed within 180 days
3. Kaolinite signal decreases after 180 days

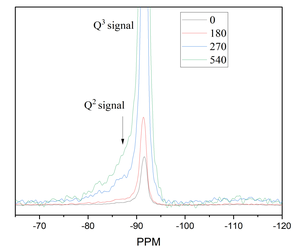
XRD



S= Stratlingite, P= Portlandite, K= Kaolinite, C= Calcite

Shows only one hydration product, stratlingite, unlike TGA, which indicates the amorphocity of the other hydration product with respect to XRD.

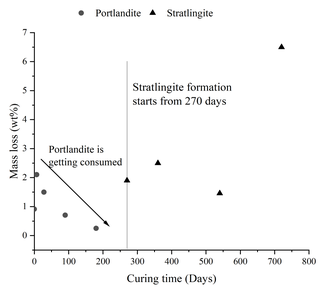
NMR

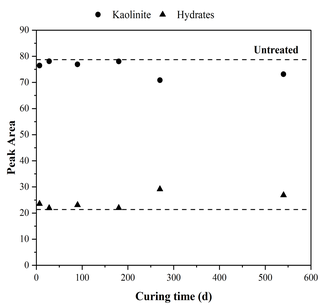


Q3 = Kaolinite, Q2= startlingite
Similar to XRD, only one hydration product is observed in Si NMR. Since NMR can observe both amorphous and crystaline products, this means that the other hydration product is a calcium alumina hydrate (CAH)

Quantitative Analysis of Clay-Lime Reactions

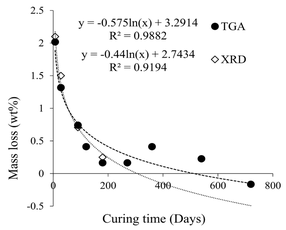
XRD & NMR



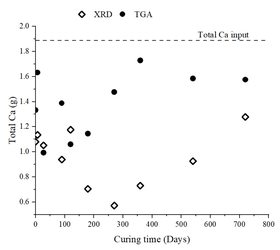


1. Both XRD & NMR show slight decrease in hydration product at 540 days of curing.
2. Following similar pattern, kaolinite peak area also slightly decreased at 540 days in NME.
3. XRD shows complete portlandite consumption after 180 days.

Comparison between TGA & SRD



Portlandite consumption:
1. XRD shows complete consumption at 270 days
2. TGA shows consumption up to 500 days, due to two outliers at 360 & 540 days



Ca mass balance:
1. Total quantifiable Ca is less in XRD after 180 days both due to portlandite consumption and amorphous hydrate.
2. TGA data plateaus after 540 days.

Concluding hypothesis

1. Due to incongruent dissolution of kaolinite, nitiallly an amorphous CSH/CAH forms from depending on preferential release of Si/Al.
2. After a year, when enough Si/Al becomes available, startlingite is formed scavanging the Ca from the earlier product and distrubing the matrix, reducing strength.