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Relationship between Strength Development and Pozzolanic Reactions in Stabilized Kaolinite

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Lime treatment of clay soils still mostly relies on empirical, qualitative understanding of the chemical reactions that drive improvement in geotechnical properties. This study contributes to the quantitative understanding of kaolinite reactions with lime over two years. Unconfined Compressive Strength (UCS) increased linearly with time, doubling within one year, followed by a 14% decrease up to two years. Strength changes were attributed to chemical reactions, as physical conditions (dry unit weight and water content) were similar for all cured samples. Spectroscopic analysis of the clay-lime system was performed at ten curing times (0, 7, 28, 90, 120, 180, 270, 360, 540 and 720 days) using three techniques: Thermogravimetric Analysis (TGA), X-Ray Diffraction (XRD) and Nuclear Magnetic Resonance (NMR) for both ^{29}Si and ^{27}Al. Both TGA and XRD showed decrease of portlandite with time up to 180 days. Fitting of the respective curves with a logarithmic trend indicated approximately 360 days for complete consumption of free lime. The TGA curves indicated an increase in hydration products associated with weight loss in the 100 to 350 ^{o}C region in the first 360 days and that increase followed a linear trend with UCS increase. No hydration products were observable by either XRD or NMR during that timeframe and no detectable changes in the kaolinite content by any of the three methods. After 360 days, growth in the hydration product TGA region slowed, and XRD showed a rapid increase of stratlingite ($Ca_2Al_2SiO_7â^{\wedge}™8H_2O$) up to 720 days, confirmed by ^{27}Al NMR; a decrease in the kaolinite signal was observed in all three methods in that time frame. Collectively, these results points to two phases in kaolinite dissolution: the first phase, up to about 360 days, is incongruent, characterized by Si release and portlandite consumption, leading to amorphous Calcium Silicate Hydrate (CSH) formation. The second phase after 360 days involves Al release and formation of CASH. It is hypothesized that CSH to CASH transformation occurs in the second stage, causing a disturbance in the cementitious matrix and loss in strength.