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A Discussion of the Paper "MECHANISM IN HARDENED CEMENT PASTES WITH HARD-BURNT FREE LIME" by Den Min, Hong Dungwen, Lan Xianghui and Tang Mingshu*

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The authors have performed a useful study in their investigation of the expansion characteristics of hard-burnt free lime in cement pastes by measuring the free linear length changes at different time periods (1). Their investigations of the hydration of lime in both water and alkaline solutions suggested that the expansion is caused by the OH^- ions present in the pore solution appearing to force $Ca(OH)_2$ crystals to form in situ and thereby promote the development of expansive forces through the pressure of crystallisation.

They note that the hydration of free lime may cause distinct expansion characteristics in different cement pastes (1). Such an observation is not altogether surprising, since calcium hydroxide formed in cement pastes is not a pure compound (2) and the rate of its formation is dependent upon the degree of clinker burning in cement kilns as well as the effects of impurities present in the cement pastes.

With cements containing hard-burnt free lime, the rate of the hydration reaction $CaO + H_2O$ --> $Ca(OH)_2$ is slower than with softer burnt free lime and arises substantially when the cement matrix has hardened. When softer burnt free lime is present, hydration to calcium hydroxide (portlandite) can occur during the plastic and early hydration period as the ferrite phase is begining to react significantly. Ferrite effectively "mops up" some of the calcium hydroxide being produced to form AFt phase (3) and consequently such lime is no longer available for an expansive reaction once the cement matrix has hardened. The slower reactivity of hard-burnt free lime means that the calcium hydroxide produced therefrom (in particular the Ca^{2+} and OH^- ions from the solution phase) is not effectively available for reaction with ferrite, as the formation of AFt and AFm phases has already arisen at this stage of the overall hydration process. Hence when hard-burnt free lime reacts there is a greater propensity (albeit at a slower rate) for more calcium hydroxide to be formed from it as a final hydration product.

Calcium hydroxide in cements, as indicated above, is not a pure material because of the large scattering of impurities amongst the clinker phases (mostly in solid solution here) and the solution phase, which lead to differences in the precise rate and extent of crystal growth development. Therefore the exact level of expansion from hard-burnt free lime will vary from one cement to another, depending upon the intrinsic composition of each cement examined.

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From the complexities of cement hydration and the solid solution effects involved with both the clinker phases and the hydration products formed, it is clear that the author's work is a valuable contribution towards our further understanding of hydration and expansion within hardened cement pastes.

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