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DISCUSSION

A REPLY TO THE DISCUSSION OF THE PAPER "UNAMBIGUOUS DEMONSTRATION OF DESTRUCTIVE CRYSTAL GROWTH PRESSURE"[1] BY L. TONG AND M. TANG

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Introduction

First of all, we would like to thank Drs. Tong and Tang for their interest in our paper and subsequent discussion, and particularly for drawing our attention to concrete destruction due to the alkali-dolomite reaction.

In our experiments, a particular system was chosen for its unambiguity, which allowed us to comment on some of the confusions as regards the generation of destructive crystal growth pressure (1). This also allowed us to delineate the necessary and sufficient conditions for matrix destruction. We are fully aware that actual destruction of a concrete structure is seldom due to a single process. However, in any idealized laboratory experiment one has to be very careful in designing the experiment as well as in interpreting the results else more confusion is added. This can be seen from the following analyses of the experiments referred to by Tong and Tang (2,3).

1. It appears that dedolomitization and demagnesitization experiments, referred to by Tong and Tang, were carried out on compacts. It is, however, known that the very process of compact formation, unless special precautions are taken, strains the compacting materials. The strain-energy stored in a compact depends on the experimental conditions and the size of the compact. The strained state of the grains could only be revealed by suitable technique, such as x-ray diffraction or petrographic microscopy. Under suitable conditions the stored strain-energy is released. Anyone familiar with the glass and stainless steel utensil-making industries is aware how explosive and destructive this release of strain energy could be. One spectacular example of this is the explosive shattering of toughened glass products when scratched with a diamond point or on impact. Even compacts of reagent-grade $CaCO_3$ expand when cycled through 0 and 99% RH. In this case strained $CaCO_3$ grains, being more soluble than unstrained grains, dissolve in adsorbed water and the dissolved materials precipitate on unstrained grains

[1]Cem. Concr. Res. 27, 811–816 (1997).
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and in the process develop local crystal growth pressure. In all the above examples the solid volume changes are very negligible

2. The solid volume reduction during dedolomitization and demagnesitization occurs only when M_2CO_3 remains in solution. If alkali carbonate (hydrated or anhydrous) or complex carbonates precipitate out, then solid volume may actually increase. For example, in the case of sparingly soluble Li_2CO_3, the solid volume increase could be about 50%. Only examination of the wet reaction mass by suitable technique can reveal the presence of alkali and/or complex carbonates. It will be of interest to perform rock cylinder tests using NaOH, KOH, and LiOH solutions and see if the expansion varies with chosen alkali hydroxide.
3. If the alkali hydroxide concentration is about 0.7 N or higher, then $Ca(OH)_2$ also forms along with $Mg(OH)_2$ during dedolomitization. The formation and crystal growth of alkaline earth hydroxide crystals may set up crystal growth pressure of sufficient magnitude to disrupt cement-based materials (4).

Which one of the above processes is primarily responsible for the observed disruption can only be evaluated by further careful work. There may be other, still unrecognized, processes as well.

We have not yet been able to obtain a copy of Dr. Gillott's paper referred to by Tong and Tang. If there was no overall system volume reduction in the set up used by Dr. Gillott, then either precipitation of alkali carbonates or some other system volume increasing processes were occurring.

However, there are some indications which cast doubt on the relevance of the dedolomitization process in concrete breakdown. It is known that dolomite aggregates from certain sources cause trouble but not those from other sources. However, dolomite aggregates from all sources undergo dedolomitization.

In our original paper, we pointed out that the precipitation and growth of a certain phase, i.e., its presence, is a necessary but not the sufficient condition for any disruption of the matrix by its crystal growth pressure. For any disruption to occur, the degree of supersaturation needs to be high enough so that the resulting crystal growth pressure exceeds the bursting strength of the matrix.

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