HR-384 Iowa Concrete Deterioration and Expansive Mineral Growth

Key Words: Expansive Mineral Growth, Ettringite, Brucite, Deicer Solutions, Chlorides, Portland Cement, Calcium Acetate, Magnesium Acetate

ABSTRACT

A significant question is what role does newly-formed expansive Mineral growth play in the premature deterioration of concrete? These minerals formed in cement paste as a result of chemical reactions involving cement and coarse/fine aggregate. Petrographic observations and SEM/EDAX analysis were conducted in order to determine chemical and mineralogical changes in the aggregate and cement paste of samples taken from Iowa concrete highways that showed premature deterioration. Mechanisms involved in deterioration were investigated.

Ettringite, 3CaO- Al203-3CaSO4 -32H20, completely fills many small voids and occurs as rims lining the margin of larger voids. Microscopic ettringite is common disseminated throughout the paste in many samples. Severe cracking of cement paste causing premature deterioration is often closely associated with ettringite locations, and strongly suggests that ettringite contributed to deterioration. Pyrite, FeS2, is commonly present in coarse/fine aggregates, and its oxidation products is observed in many concrete samples. Pyrite oxidation provides sulfate ions for ettringite formation. The oxidation of pyrite in aggregate particles appears to be affected by several factors such as aggregate type, aggregate reactivity, and pyrite size and location. Ettringite is most common in poorly performing concretes.

Brucite, Mg(OH)2, is another potentially expansive mineral that forms in cement paste of concretes containing reactive dolomite aggregate as a result of partial dedolomitization of the aggregate. No cracking was observed to be spatially associated with brucite, but most brucite was microscopic in size and widely disseminated in the cement paste of less durable concretes. Expansion stresses associated with its growth at innumerable microlocations may be relieved by cracking at weaker locations in the concrete. A second objective was to investigate whether deicer solutions exacerbate the formation of expansive minerals and concrete deterioration. Each deicer salt causes characteristic concrete deterioration by altering dedolomitization rims at the coarse aggregate paste interface, altering cement paste and/or formation of new minerals. Magnesium in deicer solutions causes the most severe paste deterioration by forming non-cementitious magnesium silicate hydrate and brucite. Chloride in deicer solutions promotes decalcification of paste and alters ettringite to chloroaluminate. CMA and Mg-acetate produces the most deleterious effects on concrete, with Ca-acetate being much less severe.