GreenCanvas

Expansive Component for Sustainable Concrete

History of Shrinkage-Compensating Concrete Production

There is a long history of expansion in both cement and concrete production along with multiple theories of the benefits as well as the cautions that should realized. It has always been so that the biggest problem. associated with concrete is the fact that it shrinks as the concrete dries out. This is the case with all concrete - even concrete that is marketed as "no slump".

Concrete expansion was initially discovered by accident over one hundred years ago when inconsistent cement production by wet process intermittently produced clinker at temperatures less than perfect. The clinker produced at lower temperatures contained certain impurities (organic and carbon-based) that surreptitiously included byproducts of aluminum compounds that changed the cement chemistry. This change in chemistry led to unexpected expansion that actually created many more problems than it could ever solve, as the expansion was never of a controlled nature. This was however, the first and earliest occurrences of expansion that when all was said and done, a structure could actually be slightly larger than it was designed to be. This "accident" of producing expansion in concrete should not to be called shrinkage-compensating concrete, however, as it could expand much more or less than needed or necessary, and this expansion was not a controlled phenomenon.

This expansion led to experimentation of the unburned material found in cement clinker and eventually, it was determined that in concrete, an addition of aluminum would emit gases that became entombed within the concrete matrix, creating an expansion of the hardened concrete. The problems arose because these gaseous pockets would disperse intermittently instead of uniformly, causing stress at different levels, and in many cases causing heightened cracking and even failures in the structures. A major reason for this was the addition of sporadic amounts at different mixing times as well as inferior mixing that would create those pockets. This addition of aluminum added to a concrete mix in order to provide expansion is actually the first generation of shrinkage compensating concrete that has been documented.

A cement chemist working in the 1930's began experimenting with kiln temperatures in order to uniformly produce a clinker that contained specific aluminum compounds that would create expansive forces. He developed a process that allowed the plants to produce expansive clinker that could be proportioned with Portland cement clinker and ground into specialty cement that would form ettringite during the first seven days after batching the concrete with this blended cement. His name was Alexander Klein and the first produced expansive cement manufactured with a specific amount of calcium sulfoaluminate for development of expansive strains within concrete was named Type K for Dr. Klein. This expansive cement became the dominant method of producing a true shrinkage-compensating concrete by the early 1940's even though

there were other offshoots of the material that react a bit differently but produce the same finished product. These subordinate cements were designated as Types M and S, with their use never quite catching on due to the degree of difficulty in production. Expansive cements, especially Type K, can be considered as the second generation in terms of just how shrinkage-compensating concrete is manufactured.

Expansive cements were the recognized production method of producing this specialty concrete from the 1960's really thru 2000, but beginning in the Pacific Rim in the 1970's another method was becoming more and more well known. It was also proven to be much easier and more user-friendly than Type K, and that was the production of shrinkage compensating concrete with a component that could be added to any quality conventional concrete mix to produce shrinkage-compensating concrete. This component used a totally different method of producing shrinkage-compensating concrete and it was not dependent upon the cement or even the chemistry of the concrete. It was manufactured under several different. proprietary trademarks but the essence of each was similar and that was to use the formation of calcium hydroxide platelets as the primary expansive mechanism.

All concrete, no matter what the cementitious, be it only Portland cement or al combination of Portland along with fly ash, slag, silica fume, etc., will form calcium hydroxide during the early hydration process. This component utilizes a portion of this produced calcium hydroxide to form platy crystals that combine with the concrete matrix in such a way as to create expansive forces within the concrete. If this concrete is restrained by reinforcement, the reinforcement develops tensile strains as the expansive forces try to stretch the steel, causing compressive stresses to build up in the concrete. After the formation of these platy crystals that essentially is complete within 24-48 hours, and after conventional curing practices, this concrete will follow al shrinkage curve that is also similar to a conventional concrete but instead of actual shrinkage, the tensile strain that has developed within the steel is relieved, ideally leaving a small residual compressive stress within the concrete. This component was initially tested by a spin-off of Construction Technologies, the testing arm of the Portland Cement Association in 2000 and the results of this testing was published in Concrete International in 2002.

It took another eight years, but in 2010, the ACI 223 committee of the American Concrete Institute was successful in seeing the new guide published and within it this component received its governance and was designated as a Type "G" Expansive component. This document, designated as ACI 223-10R, is the current Guide for the Use of Shrinkage Compensating Concrete, and Type "G" can be depicted as the latest or the Third Generation of shrinkage-compensating concrete technology.

Since it is much easier to transport a component that can be added to conventional concrete at a rate of from a low of 3-4% up to a rate of 10% depending upon the application, than it is to transport an Expansive cement, many different applications can now be considered with this specialty concrete, especially smaller types of projects. Not only can different smaller projects be considered, but different applications as well, such as the use of a Type "G" Expansive component as an SRA, use in N/S grouts, flowable fills, gunite and shotcrete operations and others that can benefit from minimal or no drying-shrinkage.

©08/21