STP1063-EB/Jul. 1990

DISCUSSION

"A Bentonite Clay Plasticizer in Masonry Mortars" - Bruce K. Dickelman

Question (Dan Walker, CHEMSTAR LIME Company):
You report that the plasticizer consists of a sodium, montmorillonite clay. These type clays will contain from 1.5 to 2.5 percent sodium and potassium, which in a seven (7) pound bag will contain the equivalent of about .25 pounds of sodium carbonate. It is common knowledge that portland cement hydrates release calcium hydroxide. Therefore a lot of the sodium in the mortar will be exchanged for the calcium in the portland cement. What happens to the sodium when it is freed into the ionic state? Sodium salts in mortars are notoriously known to cause efflorescing. Have you investigated mortars made with the clay for this problem?

It is known that aluminum minerals, such as montmorillonite clay, will react under moist conditions with sulfates and calcium to form ettringite. This formation causes a great deal of swelling to occur. Mortars made with clays will certainly have all these elements present. Have you investigated the long term expansion effects of clay mortars in high moisture conditions?

You indicate there are other additives in your clay plasticizer. Would one such additive be an air entraining material? If so, is this distinction so noted on the selling package, such as is required in C 207, Lime for Masonry Mortar? How much air content will be found in a mortar made with clay plasticizers?

Response to Question 1: (Dickleman)
It is a well known fact that montmorillonite clays contain sodium. The main objective of this ion is to increase the hydration and swelling of the clay. The degree of hydration is dependent on size, the species and the charge of the exchangeable ions, as well as the magnitude and location of the layer charge within the adjacent silicate sheets and finally, the amount of water used to hydrate the clay. If the water content is approximately 90% to 95%, the sodium tends to promote the development of many oriented water layers on the interlamellar surfaces. This hydration may produce swelling to the extent of complete dissociation of the individual crystals, thus increasing surface area and decreasing particle size. This high degree of dispersion results in a high viscosity and the sodium is in a free ionic state. In the case of sodium montmorillonite in a typical mortar formulation the water content is not sufficient to dissociate the sodium into its ionic state. However, there is enough water to achieve hydration keeping the sodium closely held to the surface of the clay and allowing it to function as a mortar plasticizer. The amount of water present in a typical mortar would have to be five to six times greater for the release of the sodium in its ionic state to occur.

Another factor effecting the sodium ion and hydration is the degree of mixing. In the practice of mixing a mortar, the agitation that is employed is not sufficient for releasing the sodium in its ionic state.

Finally, with respect to the actual amount of sodium in montmorillonite clay, you must concentrate on the total weight of the finished product. Most sodium montmorillonites contain 2.5% Na_2O. This is equal to a sodium content of 1.833%. When you consider the amount of clay being added to the total mortar, this amount is quite small. Given a typical Type S mortar formulation of: 94 lbs (1505 kg) portland cement, 3.5 lbs (56 kg) bentonite clay based plasticizer, 360 lbs (5,764 kg) mason sand, and 83 lbs (1,328 kg) water, the actual percent sodium added to the system by the bentonite is only 0.064 lbs (1.02 kg), or 0.012% of the total system weight. In short, even if all of the sodium in the plasticizer were released into the system, which cannot occur, the amount would be too small to contribute significantly to efflorescence.

Response to Question 2: (Dickleman)
Two restrictions apply to the lack of formation of ettringite with the combination of montmorillonite clay, sulfates and calcium. The first again is moisture. As I explained above, the actual moisture content used in relation to the clay is actually quite small. Secondly, ettringite, which is $6CaO.Al_2O_3.3So_3.33H_2O$, would have to react with the aluminum in the octahedral layer of the montmorillonite. In order for the montmorillonite to react the aluminum would have to be released from its octahedral layer. This cannot occur with the lack of water, and mixing, etc.. The aluminum is held very strongly in the octahedral layer.

Response to Question 3: (Dickleman)
Although predominantly comprised of bentonite, there are indeed other ingredients included in the production of this product. These ingredients, including the addition of air entraining materials, if any, are proprietary and will remain so.

Hydrated lime is a cementitious material and therefore must conform with the requirements of ASTM C226-86, "Standard Specification for Air-Entraining Additions for Use in the Manufacture of Air-Entraining Portland Cement". It is this specification that grandfathered the referenced, imposed requirement in ASTM C207-79 "Standard Specification for Hydrated Lime for Masonry Purposes". This bentonite clay based plasticizer is not considered cementitious and therefore, does not fall under the requirements of this specification. On a more fundamental basis, there is no vehicle by which this plasticizer can be recognized by ASTM C270-88 "Standard Specification for Mortar for Unit Masonry", so mandatory compliance to any ASTM specification is moot.

The laboratory air content of mortars made with this bentonite clay based plasticizer generally range between 12% and 18%, depending upon the mortar Type.