Texas Aggregate and Concrete Association

Position Statement #9

Dealing with Concrete in Sulfate Soils

As the second most used product on earth, concrete is a great material with an extensive list of competitive advantages over other building materials. Concrete is relatively economical, which provides for an excellent choice for use in pavement construction. While considered a durable construction material, it still requires a good foundation to build upon. However, with the many different types of soil conditions that exist careful analysis of the soil's properties is a must to ensure an adequate foundation to build upon. Soils contain sulfate minerals such as, sodium sulfate, calcium sulfate, and magnesium sulfate which react with the sulfate ion and hydrated calcium aluminate and/or the calcium hydroxide components of hardened cement paste in the presence of water; the products that result from this reaction are ettringite and gypsum. These reactions are expansive and can lead to internal pressure in hardened concrete resulting in the softening and cracking the concrete structure. To assist in lessening the reactions that may form from these sulfate soils, which in themselves can become expansive in nature, stabilizing the soils in question has become a prerequisite to installing concrete structures.

The state of Texas has its fair share of pavement structure projects. These projects regardless of whether they are constructed with concrete or asphalt are susceptible to destruction brought on by heaving soils. These expansions can occur after a single rainfall or may take years to come about resulting in pavement distortion. It is therefore crucial that the soils in question be dealt with in a proper manner. Like many other states, Texas too has its own set of soil conditions to deal with and chief among them is the presence of soluble sulfates. These natural sulfates are found in soils, ground water, rivers, ponds, and seawater. Additionally, soils may become contaminated with sulfates from manmade sources, such as sanitary waste, industrial waste, and agricultural waste. Over the past two decades Texas Department of Transportation (TxDOT) has had much experience with soluble sulfates containing soils. There have been pavement failures which are the direct result of sulfate induced heave of the underlying soil. Induced sulfate heave is a result of expansion brought on by ettringite formation within the soils. The ettringite is created by a reaction between added calcium based materials, water, and clays and sulfate minerals found within the soils. The ettringite created by this reaction can result in the growth of crystals that can expand to 2 to 2 1/2 times their previous volume, thus resulting in the induced heave. While it may be necessary to replace some soils that contain high levels of sulfates, it is not always the first choice, due to the cost.

Texas has had much success with stabilizing soils with calcium based additives, such as cement and fly ash. Through research conducted by the Texas Transportation Institute (Report FHWA/TX-06/0-4240-3), it was found that there are options to replacing soils. Research showed that in many instances soils containing soluble sulfates up to 7000 ppm could be stabilized with traditional lime and other calcium based products. However, there are alternatives available for minimizing or eliminating the potential for soil disruption due to the presence of soluble sulfates when calcium based additives can not perform the job on their own. In those cases where soluble sulfates run above the 7000 ppm, alternative products could be used to effectively stabilize these soils. These products included, Ground Granulated Blast Furnace Slag plus lime, and Class F fly ash, plus lime.

Soil conditions must be dealt with in a constructive manner to ensure the long life performance of the concrete pavement. As outlined in TxDOT Guidelines for Treatment of Sulfate-Rich Soils and Bases in Pavement Structures, it is recommended that soil samples be taken every 500 feet and in cut sections samples should be taken at the final grade of elevation of the subgrade. Once the samples have been retrieved they are to be tested for sulfate concentration using TxDOT test method Tex-145-E. Another test method would be using Tex-146-E, which is a field method for measuring soil conductivity. Once these areas and levels have been identified proper treatment of the affective soil can then be performed.

Soluble Sulfates can be destructive mechanisms which cause a chemical reaction between the sulfate ion and hydrated calcium aluminate and/or the calcium hydroxide components of the stabilizing material. It is therefore prudent to ensure that the appropriate action is taken to eliminate or reduce this potential hazard so as to ensure good quality construction. TxDOT recognizes these areas of concern and through their instituted preliminary steps and corrective actions, problems which may arise from soluble sulfates in the field are minimized.

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