DESIGN AND CONSTRUCTION UPDATES

Alkali-Silica Reaction (ASR)

FAA standard specifications contain numerous testing requirements for the materials used in pavements. Sometimes these tests seem to be too expensive, take too much time to conduct, or not provide any valuable information. Occasionally we experience asphalt aggregate stripping problems or raveling of porous friction courses where the required asphalt cement additives were omitted. Most all engineers realize the importance of conducting tests to avoid these types of problems in asphalt since they are common. We have recently experienced alkali-silica reaction (ASR) problems in a couple of Portland cement concrete projects. Although ASR has been observed for over 50 years, not all engineers are aware of the problem.

What is ASR? ASR is a deleterious chemical reaction between the aggregate and the surrounding cement paste. The most common reaction is that between the active silica constitutes in the aggregate and the alkalis in the cement. The reaction starts with the attack on the siliceous minerals in the aggregate by the alkaline hydroxides derived from the alkalis in the cement. As a result, an alkali-silicate gel is formed, and alteration of the borders of the aggregate takes place. The gel is an unlimited swelling type by imbibing water and increasing in volume. Since the gel is confined by surrounding cement paste and aggregate, internal pressures eventually result in expansion and cracking of the cement paste. The reaction may not occur for several years depending on temperature and size of the siliceous particles. It is identified by a hand- to foot-size cracking pattern. The following photos show the cracking pattern and deterioration from ASR.

The expansion eventually effects adjacent structures and pavements. Structures may not withstand the pressures and pavements will heave or buckle.

Why do we see it now? This is partially due to suppliers developing new aggregate sources or expanding to other areas of the pit or quarry where track records are not available. Also with increasing air quality requirements for the cement producers, the dust (containing alkalis) that would previously go up the stack is now being reintroduced back into the cement product. ASR can take several years to react.

What is in the FAA specifications to test for in order to prevent this reaction? The P-501 specification contains test requirements starting from aggregate past performance and petrographic examination to actual mortar bar testing for identifying and eliminating this type of deterioration. The specification also refers to ASTM C-33 criteria for aggregate quality that devotes an entire appendix to this problem. In addition , the Northwest Mountain Region Specification Notice contains additional testing to identify it. If it is identified, prevention can be handled several ways. The first is to use a different aggregate source or by using low-alkali cement. The expansion can also be eliminated by adding a sufficient quantity of reactive silica to the mix in a powdered form. Type F flyash happens to be essentially all silica and its addition (in sufficient quantity) stops the reaction from ever occurring at minimal or even a reduction of cost.

What can you do if it exists? There is no proven method for overlaying or sealing to stop this reaction. Individual slabs will eventually have to be removed and replaced when the deterioration presents FOD problems or damage to adjacent structures from the pressures. When this occurs, adjacent slabs will expand even more rapidly without the restraints. Eventually the entire area will have to be reconstructed. Recent testing shows some promise for the use of a lithium to slow the reaction. It is sprayed on the surface in a sufficient quantity to saturate the cracks and retard the alkali-silica reaction. This, however, is not anticipated to be a permanent repair.

Grade Design and Construction Control for Asphalt Overlay Projects

The majority of FAA grant projects include overlay of existing asphalt concrete (AC) pavements. The standard FAA specifications include requirements to accept the final grade based on 50-foot survey intervals. Not all projects include enough information in the design or the contract documents to control or accept grade. These projects are typically designed to overlay a given thickness of AC and may include some cold milling to a specific depth. This type of design reduces the survey effort for design and inspection of the project. The problem is loss of control for the pavement grade since none is designed or specified. The surface smoothness is the only control remaining. Without an adequate design survey, a designer cannot evaluate whether profiles meet design standards or if any improvements are necessary. The contractor can also introduce variations in the milling or paving that are not evident in smoothness testing.

Grade is an important factor in the ride and behavior of aircraft. While the smoothness is measured over a relatively short distance with a 12- or 16-foot straight-edge or a 25-foot profilograph, the grade is the means to control the smoothness over the longer distance which affects the aircraft ride.

All pavement projects are to be designed to include a profile and sufficient information for grade control at the required 50-foot interval. A simple check for an adequate design is whether specific cross-sections can be drawn at each 50-foot interval or a table can be developed during design to evaluate grades. Projects that are designed to control only thickness of the pavement do not meet FAA standards.

Paint Curling

Our region, as well as other regions, have been experiencing curling of the new airport pavement markings. The curling is typically at the edges of the marking and will chip off under traffic.

The problems appear to occur with waterborne paints and coincide with recent changes to the FAA specification, P-620. The exact cause is not known; however, the dry film thicknesses of the paint chips are in excess of 15 mils. The most probable cause is the paint shrinkage during drying creates tensile stresses in the paint film. The thicker films have more shrinkage and overall greater cohesive strength than the thinner films. The tensile forces eventually exceed the adhesion strength at the edges and they de-bond and curl. In some cases, on slurry seals the failure will occur at the weakest plane, between the slurry and the original surface.

The P-620 specification requires that the paint be applied at a maximum of 115 square feet per gallon which is equivalent to a minimum of 13.9 mils wet film thickness or about 8.3 mils dry film thickness. The contractors and inspectors should be aware of the maximum film thickness as recommended by the manufacture and not exceed it.

Sulfate Reactions

Sulfate-induced heave in lime or Portland cement treated clay soils was first reported 1986, although it was evident since 1958. This heave has the potential to occur in lime or cement stabilized clays when certain concentrations of soluble sulfates are present in the soil or groundwater. Loading will not effect the expansion since the ettringite crystals, when restrained, can exert pressures up to 35,000 p.s.i.

The same ettringite formation which causes this heave in soil can destroy Portland cement concrete (PCC) structures exposed to high concentrations of sulfates. PCC pavements normally will not be exposed to the sulfates unless placed directly on high sulfate subgrades. Drainage structures and foundations are exposed.

The reaction in PCC is controlled by the addition of flyash (Pozzolan type F) in the mix and including a maximum specified 5% of C_3A (Type V) for the Portland cement. Although there are some techniques and possible additives which will stop the soil reaction and heave, the most sure method is to not use lime, type C pozzolan, or Portland cement to stabilize.

The foundation exploration and testing of soils and groundwater for projects should include a check for soluble sulfates in areas with clay subgrades and where lime or Portland cement stabilization is considered.

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