Florida Department of Transportation Research

Performance Improvement of High Early Strength (HES) Concrete for Pavement Replacement Slabs

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Current Situation

Sections of concrete roadways occasionally need replacement. To do so, a slab must be removed and a new slab placed in its stead. This requires lane closure, and re-opening the lane as soon as the concrete will allow is a goal. High early strength (HES) concrete, specific concrete mixes that achieve adequate strength within a few hours, are often chosen to minimize lane closures. However, the Florida Department of Transportation has noted an unacceptably high level of cracking in newly installed slabs for a number of replacement operations. These procedures are all conducted under standard protocols, so the reasons for higher cracking rates are not clear.

Slab replacement crews often work at night to reduce the time that lanes are closed to traffic.

Research Objectives

University of South Florida identified concrete mixtures and slab base-restraint and placement conditions that can reduce the risk of early-age cracking in concrete pavement repair slabs.

Project Activities

A battery of laboratory tests and field slab placements were conducted to assess strategies to reduce cracking in pavement concrete slabs. Strategies studied here were cementitious paste volume reduction through aggregate grading optimization, lightweight aggregates (LWA) for internal curing, fibers to increase tensile strength, shrinkage-reducing admixtures, and geotextile and plastic sheeting for sub-base to minimize restraint. Field slabs were instrumented with stressmeters and thermocouples. Software used to identify the main factors affecting cracking potential in concrete slabs were DIANA for finite element analysis and HIPERPAV for analysis of the early-age behavior of concrete pavements.

The findings indicated that the initial stress development in most of the field-placed slabs was affected by moisture migration to the base layer. Concrete shrinks as it dries, and increased shrinkage was observed with the mixes tested, resulting in tensile stresses. Finite element analysis confirmed that the initial unequal cooling between the edges and the interior of the slab would not contribute to the development of tensile stresses within the slab at early ages.

Testing also indicated that cracking risks of HES concrete can be greatly reduced by increasing the aggregate packing density and lowering the paste content. The cracking probability of HES concrete slabs can be also minimized by incorporating saturated LWA as a means of extending hydration (internal curing) and reducing shrinkage effects. It was found that polyethylene sheeting reduced early-age stress development more by reducing base moisture absorption than by reducing friction. In contrast, geotextile increased moisture migration from concrete slabs, increasing cracking risks during early age.

Project Benefits

The more detailed understanding of the use of HES concrete for slab replacement will help assure the performance of replacement slabs and reduce repair time and costs as well as interruptions of traffic.

For more information, please see www.fdot.gov/research/.