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Research at a Glance

Technical Brief

BUREAU OF RESEARCH

Innovative Techniques and Materials for Preventing Concrete Shrinkage Cracking

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Modern concretes used in transportation infrastructure have high strength, lower permeability, and excellent durability. However, because of the high cementitious content, low water-to-cementitious material ratio, and various admixtures, modern concrete in transportation infrastructure often possess a high risk of shrinkage cracking. Many states have reported cracking on transportation infrastructure, particularly on bridge decks at early ages, which is also a concern in New Jersey.

Research Problem Statement

Cracks weaken concrete and permit water and harmful chemical ingress into structures. It, therefore, facilitates concrete deterioration and the corrosion of reinforcement. Shrinkage also causes concrete slabs to curl and warp, which can decrease the load-carrying capacity.

This study investigates shrinkage cracking prevention of infrastructure concretes used in New Jersey. More specifically, it is to identify the significant shrinkage components currently present in New Jersey concretes known to have had issues with shrinkage and the application of recent innovations (shrinkage reductions, compensation, internal curing, coatings, and fibers) in shrinkage cracking mitigation.

Research Objectives

The study aims to improve the longevity and performance of New Jersey transportation infrastructure by reducing the concrete shrinkage and cracking potential and limiting the ingress of water and other deleterious substances into the concrete. Innovative techniques and materials for preventing shrinkage were studied in New Jersey materials and conditions to achieve this goal. The following set of specific objectives was set:

1. To identify and measure components of shrinkages in New Jersey concretes;
2. To identify and investigate different methods for controlling shrinkage cracking applicable to New Jersey infrastructure concrete mixes.
3. To determine the effects of the techniques and methods used to control shrinkage cracking on other fresh and hardened concrete properties.

Methodology

Fifteen mixtures were first evaluated on their shrinkage behavior. The shrinkage tests used were autogenous shrinkage, drying shrinkage, and restrained ring shrinkage cracking. Based on the results of the tests, control mixtures with high shrinkage potential were selected for modification with shrinkage control admixtures and additives. The admixtures and additives were a shrinkage-reducing admixture (SRA), a shrinkage compensating admixture (SCA), an internal curing agent, which was a fine lightweight aggregate (LWA), fibers, and two surface coatings. The surface coatings were lithium silicate (LS) and a polymer-modified cementitious binder (EN). The surface coatings were designed for surface strengthening but were included to investigate if they affected concrete shrinkage.

The modified mixtures were then tested for the effects of the admixtures and additives on autogenous shrinkage, drying shrinkage, and restrained shrinkage. The mechanical properties of the modified mixtures were also measured. These mechanical properties were compressive and tensile strength, elastic modulus, and creep. The modified mixtures were also tested for electrical resistivity and resistance to cyclic freezing and thawing to evaluate their durability. Finally, small slabs made from the modified mixtures were exposed to field conditions to measure their shrinkage behavior.



Results

The results showed that the cracking potential of the original fifteen mixtures ranged from moderate-low to high. The mixture autogenous shrinkage increases with the increase of fine aggregate volume or decrease of coarse aggregate volume. On the other hand, an increase in portland cement and total binder while decreasing the amount of fine and coarse aggregates tends to increase the drying shrinkage. Incorporating admixtures and additives in the two selected control mixes had varying effects on autogenous, drying, and restrained ring shrinkage. The SRA was effective at reducing the concrete's shrinkage and cracking potential. The SCA did not reduce the autogenous shrinkage of the concrete but reduced the drying shrinkage when the maximum dosage was used. Surface coating EN slightly reduced autogenous and drying shrinkage. However, LS reduced autogenous shrinkage but not the drying shrinkage. Internal curing with LWA reduced the autogenous shrinkage and cracking potential but not the drying shrinkage. Also, incorporating fibers reduced the autogenous shrinkage and the cracking potential. The SRA, SCA, fibers, LS, and EN do not adversely affect concrete's strength and elastic modulus. It was also observed that SRA was more robust than SCA in reducing shrinkage when exposed to field conditions.

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