PROJECT SUMMARY

Texas Department of Transportation

0-6332: Development of Predictive Model for Bridge Deck Cracking and Strength Development

Background

Early-age bridge deck cracking has been found to be a prevalent problem in the United States and worldwide. While early-age cracking will not cause failure of a bridge deck system independently, the penetration of deleterious substances through the early-age cracks into the bridge deck concrete and the bridge superstructure can lead to costly serviceability issues, and possibly the loss of some structural integrity.

Bridge deck cracking is a multi-mechanistic process, affected by various volume change mechanisms, strength development, and the restraint conditions of the system. Before the concrete has even set, plastic shrinkage cracking due to water loss to the environment must be avoided. At an early age, the volume changes associated with the hydration reactions taking place can lead to chemical and autogenous shrinkage. After the curing system has been removed, the concrete must be able to withstand the drying shrinkage that will occur over the life of the structure. Thermal deformations, both as a gradient and as a bulk temperature change, can lead to significant stresses in the concrete system at both early and later ages. Restraint conditions and a changing elastic modulus turn these various volume changes into stresses, which must be resisted by the developing strength of the concrete and through relaxation from concrete creep.

This project evaluated several of the key volume changes and sources of stress that affect bridge deck cracking. The researchers performed extensive laboratory and field research, and implemented the final results into a newly developed bridge-deck-cracking module within ConcreteWorks, a multifaceted software program developed by the same researchers under previous Texas Department of Transportation (TxDOT) funding.

What the Researchers Did

The research objectives were addressed in this project through a combination of laboratory tests, field evaluations, and computational modeling. A wide range of materials and mixture proportions were studied in the laboratory, with focus on:

- Drying shrinkage.
- Autogenous shrinkage.
- Heat of hydration.
- Mechanical property development (compressive strength, elastic modulus, and tensile strength).

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Center for Transportation Research

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In addition, several bridge decks constructed in Texas were instrumented to validate and calibrate the heat of hydration models developed under this project. Concrete test specimens were obtained from each deck placement and evaluated for early-age strength development and heat of hydration.

What They Found

Some of the most important findings from this study include:

- Heat of hydration models were developed that accurately predict heat generation in bridge decks for a range of concrete mixtures containing various cement types, supplementary cementing materials, and chemical admixtures.
- A new creep model was developed that allows for both the prediction of early-age and later-age creep, which are essential factors when predicting stress development in bridge decks.
- A tool for assessing the risk of plastic shrinkage was developed, which couples the role of evaporation and setting time (through the use of a newly developed setting-time predictive model).

What This Means

This research project has implemented the main findings from this project into a new concrete bridge-deck-cracking module within ConcreteWorks. It is expected that this new module will serve as a useful tool by which TxDOT can improve the performance and durability of concrete bridge decks, which in turn will help to prolong the life of the transportation infrastructure in the state of Texas.

For More Information

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