Documentation of the INDOT Experience and Construction of the Bridge Decks Containing Internal Curing in 2013

Introduction

The Indiana Department of Transportation (INDOT) constructed four bridge decks utilizing internally cured, high-performance concrete (IC HPC) during the summer of 2013. These decks implement findings from the research presented in the FHWA/IN/JTRP-2010/10 report in which internal curing was proposed as one method to reduce the potential for shrinkage cracking, leading to improved durability. The objective of this research was to document the construction of the four IC HPC bridge decks that were constructed in Indiana during 2013 and quantify the properties and performance of these decks. This report contains documentation of the production and construction of IC HPC concrete for these bridges. Samples of the IC HPC used in construction were compared to a reference high performance concrete (HPC) which did not utilize internal curing. The samples collected in the field were transported to the laboratory, where the mechanical performance, resistance to chloride migration, and potential for shrinkage and cracking were assessed. Using experimental results and mixture proportions, the diffusion based service life of the bridge decks was able to be estimated. The intent of this report is to provide data that can be used to quantify the performance of internally cured concrete, with the goal of developing a strategy to determine if and where internal curing should be used by INDOT.

Findings

The construction process was documented for four bridge decks made using IC HPC. These concretes were able to be designed, batched, and placed and are now in service. While avoidable issues were observed...
during batching construction related to corrections of water, batching tolerances, and fluctuations in air content (which apply to any concrete), the IC HPC was able to be batched and placed using slight modifications to conventional methods. The production of the IC HPC mixtures was implemented using a mixed specification with prescriptive and performance-based measures representing an improvement on previous specifications, which did not specifically have provisions that consider durability. To aid in the implementation of internal curing in the field, a new quality control technique for lightweight aggregate utilizing a centrifuge has been developed and is now standardized in Indiana Testing Method 222. Additionally, a series of spreadsheets that automate calculations necessary for quality control for lightweight aggregates, mixture proportioning, and moisture adjustments have been made available as a part of this report (see Appendix G and Appendix H).

The results of laboratory testing indicate that the compressive strength, modulus of elasticity, and tensile strength of the IC HPC mixtures were not substantially different than those of the HPC mixtures, and as such current codified equations can be used to predict the modulus of elasticity and tensile strength if the compressive strength is known. The chloride migration of these concretes was assessed, and it was shown that each of the mixtures tested had a charge passed in the rapid chloride permeability test of less than 1500 C at 91 days. Additional testing provided equivalent results when performing the Nordtest, Stadium migration test, or electrical resistivity test. Using experimental results to determine the chloride diffusion and permeability of each mixture in conjunction with the mixture proportions and chemical compositions of the cementitious materials, the initiation time of the diffusion-based service life of the IC HPC bridge decks was estimated to be between approximately 60 to 90 years, compared to approximately 18 years for conventional Class C bridge deck concrete used in Indiana. The susceptibility to early age shrinkage and cracking was evaluated where it was shown that IC HPC concretes exhibited a reduction in early age shrinkage of 70 to 90%, resulting in a reduction in residual stresses of 80% or more while reducing thermally induced stress by up to 55% when compared to HPC mixtures. Collectively, these results indicate that the IC HPC mixtures produced as a part of this study exhibit the potential for substantially increased service life while markedly reducing the potential for early age cracking.

**Implementation**

It should be emphasized that the implementation of such technologies as presented within this report alone does not guarantee higher performance, as the production of such concrete requires a degree of technical competence in design, production, and construction of concrete materials. As is the case with the production of any concrete, internally cured or not, performance will be directly tied to the careful accounting of water, be it on the surface of aggregates, in the mixing drum after washing, or elsewhere. Special attention should be paid to the proper operation of batching systems due to complexities with entering “jog rates” and moisture contents, while placement techniques should be reviewed to minimize unwanted effects, and proper finishing and curing techniques must always be practiced. Only after performing the basics of concrete production properly will the full benefits of internal curing be actualized.

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