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SUMMARY REPORT

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Evaluation of Rapid Set Patching Materials for PCC Applications

EXECUTIVE SUMMARY

Introduction

A wide variety of rapid set patching (repair) materials are available in the concrete industry for use with repairs on concrete pavements, bridges and structures. These materials possess a broad range of physical and mechanical properties. Among the principal reasons for premature failures of concrete repairs is the improper selection of repair materials, without adequate knowledge of the compatibility between the properties of repair material and the substrate concrete. The purpose of this research study is to conduct an experimental program to determine the physical and mechanical properties of selected repair materials from the SCDOT list of approved repair materials for PCC application, and develop a test methodology to assess compatibility of the repair materials with substrate concrete.

Research Program

In this research study, properties of eight different cementitious repair materials and one substrate concrete were investigated in three stages. First, properties of repair materials such as setting time, flow, compressive strength, flexural strength, split tensile strength, slant-shear bond strength, drying shrinkage, freeze-thaw resistance, and permeability, were determined using standard ASTM test procedures. Specific emphasis was placed on determining the bond strength of the repair materials using slant-shear bond strength (ASTM C 882) at different ages. Second, the compatibility between the repair materials and substrate concrete was investigated using a flexure test on a composite beam (consisting of a notched substrate concrete section repaired with a rapid set patching material) under third point loading. Third, correlations between the individual properties of repair materials and the performance of the composite beam under flexural loading were explored to predict the compatibility of the repaired concrete. Based on these studies, a test method is proposed to examine the compatibility between

repair material and substrate concrete for future evaluations of repair materials.

Results

Results from this study indicated that although physical and mechanical properties of different repair materials were superior individually, their performance in a composite section such as the slant-shear bond strength test was found to be a function of factors such as relative strengths (both compressive and flexural strengths) between repair materials and substrate concrete and surface texture on the substrate concrete. Based on these findings it was observed that slant-shear bond strength test may not provide a consistent basis to evaluate different repair materials. In its existing procedure, this test method lacks specific guidance on factors such as surface texture to be applied on substrate mortar and compressive strength of the substrate mortar relative to the strength of the repair material. Further, this test method does not simulate realistic stress conditions faced by the repair materials in field conditions.

In order to better understand the compatibility between the repair material and substrate concrete in the second stage of this research investigation, composite beams of repair material and substrate concrete were prepared and tested in flexure to simulate tensile stresses in the repaired section. Tensile stresses are generally observed in the negative moment regions of a bridge deck or in cantilevered sections of a concrete structure, where the tension in the concrete repair is induced by imposed loads or due to environmental conditions. In this study, the flexural strength, the failure patterns and the load-deflection curves of the composite beam specimens were determined and compared with the results from tests on a control beam (i.e. substrate concrete alone) to assess the compatibility. In addition, the influence of three curing conditions on the material compatibility was evaluated. Compressive strength, flexural strength, split tensile strength, and drying shrinkage of the repair materials and substrate concrete were investigated to aid in the analysis of the compatibility. In this study, the compatibility of repair material and substrate concrete was found to be a function of (i) flexural strength of composite beam as compared to control, (ii) failure patterns (de-bonding and edge cracking), and (iii) behavior of load-deflection curves. It was observed that significant differences in compressive and flexural strength between the repair material and substrate concrete caused incompatible failures. In addition, high drying shrinkage of the repair materials also caused the incompatible failures.

In the third stage of this research, correlation between individual repair material properties such as compressive strength, flexural strength, bond strength, and drying shrinkage, and the performance of the composite beam under flexure loading (compatibility) was investigated. From this study it was observed that no strong correlation exists between the individual repair material properties and the performance of the composite beam under flexural loading.

Conclusions

Based on the findings from this study, it is concluded that although properties of repair materials such as compressive strength, setting time and others are important from an operational standpoint (i.e. opening up the repaired section to traffic), these properties do not correlate well with the long-term field performance of the repaired composite section, and as such do not predict the compatibility of the repair material with substrate concrete. Further, the slant-shear bond strength test was found to be inadequate in properly characterizing the compatibility of the repair material with substrate concrete. The performance of composite beam under flexural loads (i.e. flexural strength, load-deflection behavior, and failure mode) as proposed in this study, has been found to better characterize the compatibility between repair materials and substrate concrete. It is proposed that this test method be further developed into a standard that can be adopted to evaluate compatibility of repair materials, and study the effects of mechanical and environmental factors that affect the long-term performance.

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