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Development of the MASW Method for Pavement Evaluation

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Infrastructure deterioration is a major issue for transportation infrastructure in the southern plains region and around the nation. Delamination, cracking, and many other failure modes in bridge decks and pavement systems are a daily issue in the constant maintenance of transportation systems. The extreme weather across the nation further exasperates the problem of failing infrastructure by increasing the wear and tear on transportation systems through more frequent freeze-thaw cycles and larger temperature swings. To combat these problems in an economic way, highway departments need non-destructive testing (NDT) methods to determine the condition of infrastructure and the rate of decay to better plan for future repairs and replacement of transportation systems. The Multi-Channel Analysis of Surface Waves (MASW) is a NDT method developed as an improvement to the Spectral Analysis of Surface Waves (SASW) method for dynamic characterization of soil for geophysical and geotechnical engineering problems.

This research aims to develop the MASW method into a tool for characterization of concrete and asphalt pavements, bases, and subgrades for transportation projects. In addition, the method can be utilized for detecting damage to infrastructure such as bridge decks. Early detection of delimitations, cracks, and concrete deterioration can be critical for planning future repairs or replacement of the existing infrastructure, which could potentially save highway departments money in during both the infrastructure inspection and the repair/ replacement phase.

To develop the MASW method as a transportation tool, the following three tasks will be completed. (1) Determine the optimal field data collection parameters for both concrete and asphalt pavements including source type, source location, number of receivers, receiver spacing, and receiver coupling. (2) Determine the practical vertical and horizontal resolution with depth of MASW given the optimal arrangement provided from the first task. This will provide a baseline for the methods ability to resolve problem areas in the pavement, base, and subgrade system. (3) MASW will be used on real bridge decks and pavement surfaces that show signs of deterioration to determine if the method is able to detect the damage when the damage is already apparent by visual inspection. The results will be compared to results from more proven methods such as SASW and Impact Echo to insure the accuracy of MASW.

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Evaluation of Surface Treatments to Mitigate Alkali-Silica Reaction

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ASR is an expansive reaction between the alkalis in the cement and reactive silica in the aggregates. Arkansas is currently witnessing the detrimental effects of ASR at various locations in Arkansas. These locations include many miles of interstate pavements and interstate barrier walls (locations in both Central and Northwest Arkansas). A petrographic analysis of samples from select locations has confirmed that ASR is present in these areas. Therefore, prevention and mitigation measures must be developed.

Current research at the University of Arkansas is examining methods to prevent ASR occurring. This project builds upon the current research and examine methods to slow or stop ASR once it has occurred in concrete structures. Research at the University of Arkansas has shown that concrete expansion due to ASR may be exacerbated by the extreme weather changes that Arkansas has experienced during the recent winter. This weather change has resulted in additional freezing and thawing cycles in ASR infected structures and has caused further deterioration. Concrete cracking due to freezing and thawing has allowed additional water into the structures which accelerates ASR. The project will examine the effectiveness of silane when freezing and thawing cycles are common.

For the project, concrete blocks will be cast with an aggregate that is known to initiate ASR. These will be stored outside and subjected to ambient conditions which include the extreme summer temperatures as well as freezing and thawing cycles. The blocks will be instrumented to measure expansion and relative humidity. Each block will be treated with silane and other potential sealers. Sealer application rate and dosage rate will be varied. The objective of the project is to identify an effective sealer, dosage rate, and application rate for stopping the ASR.

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Evaluation and Repair of Existing Bridges in Extreme Environments

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Aging or deterioration of our nation's bridge infrastructure is a significant problem that requires immediate attention. In general this infrastructure deterioration can be attributed to two main factors, 1) corrosion, and 2) metallic fatigue, both of which work together to reduce structural capacity over time. With our existing bridge infrastructure subjected to ever-intensifying environmental conditions and everincreasing freight truck traffic, deterioration rates will likely increase. Safely extending bridge life using localized retrofits is an economical and fast alternative to complete bridge replacement; however, such retrofits must be resilient to further corrosion and fatigue. Both steel and concrete bridges are susceptible to corrosion and fatigue strength losses.

The goal of this project is to produce comprehensive strategies for evaluation and resilient repair of prestressed concrete and steel bridge girders subjected to extreme environments in order to increase the longevity of existing structures. The effect of end region steel corrosion on capacity of prestressed concrete girders will be examined, with the objective of producing rating procedures related to corrosion level and repair designs incorporating residual strength. Innovative design strategies for corrosion resistant steel bridge fatigue retrofits will also be explored, to protect against environmental extremes and extend bridge fatigue life under increased levels of freight/truck traffic.

Concrete bridge issues will be examined through a series of tests on scaled prestressed concrete girders subjected to accelerated corrosion. These tests will identify how end zone corrosion affects member strength through concrete deterioration and loss of bond with the prestressing steel. The results will be utilized to assess levels of corrosion for evaluation and accurate residual strength for use in design of retrofits. Retrofit methods will be examined with a focus on carbon fiber reinforced polymer (CFRP). Tests will be conducted to determine the effectiveness of repairs. Steel bridge issues will be addressed by first identifying "fatigue critical zones" using detailed finite element analysis. Prestressed CFRP retrofit solutions focused on mitigating fatigue crack initiation will be developed for the critical zones using a finite element parametric study. Methods for optimizing these solutions to best shift the mean stress into a safe range for fatigue will be developed along with corrosion resistant application and bonding strategies. The results of the two distinct aspects of the project will be synthesized to produce comprehensive recommendations.

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Impact of Extreme Summer Temperatures on Bridge Structures

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This research project focuses on investigating the effects of extreme temperatures on prestressed concrete bridges. The project includes three parts: (i) a laboratory and experimental investigation, (ii) development of a computer program, and (iii) finite element modeling of the stress distribution due to temperature variations.

The laboratory and experimental investigation will measure temperature distribution in two full-scale sections of a BT-72 bridge girder. A sections of the BT-72 girder will be instrumented and stored outdoors a the Engineering Research Center of University of Arkansas and at Fears Structurally Engineering Laboratory at the University of Oklahoma.

The computer program will be developed using Microsoft Visual C++ to determine the temperature distribution and the corresponding thermal stresses in the girder cross-sections. This program will be used for six AASHTO I girders and three AASHTO-PCI Bulb-Tee sections. The finite element modeling includes two-dimensional and three-dimensional models. The two-dimensional model will be used to determine the temperature distribution within the girder cross-sections. The two-dimensional model will be used to investigate the global behavior of the girders including the bridge deck.

The project will propose a new thermal gradient model accounting for the effects of extreme temperatures. A computer program will be developed to assist the quantification of the thermal stress distribution within prestressed concrete bridge girders. The minimum reinforcement ratio and placement of non-prestressed reinforcement will be refined based on the research findings.

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