I. RESEARCH PROJECT TITLE

Characterizing KDOT's Chloride Permeability Testing Protocol: Reducing the Duration of the Rapid Chloride Permeability Test

II. RESEARCH PROBLEM STATEMENT

Reliable and economical design of PCC pavement structural systems relies on various factors, among which is proper characterization of the expected permeability response. Permeability is an extremely important factor that strongly relates the durability of PCC pavement systems to prevailing environmental conditions. For this reason, KDOT uses the Rapid Chloride Permeability testing protocol to determine the resistance of concrete to water, chlorides and other chemical intrusion. Typically, the Rapid Chloride Permeability test measures the number of coulombs that pass through a concrete sample over a period of six hours at a concrete age of 56 days. Results of this test make it possible to obtain the desired time-dependent concrete permeability response.

During the past years, KDOT has performed numerous full, six-hour permeability response tests. Unfortunately, KDOT has not been able to capitalize on the richness of the available full-response permeability database in order to shorten the testing duration. Accordingly, it is proposed herein that we utilize the statistical/artificial neural network (SANN) approach for the development of appropriate SANN-based models that can effectively project the full six-hour response from a shorter-duration permeability response. The proposed research is in direct response[1] to KDOT's need to reduce the testing time of the currently used KDOT rapid chloride permeability test. The proposed project constitutes the first phase of a potentially three phase sequential research project that aims at efficiently characterizing the entire KDOT Chloride Permeability Testing Protocol.

III. RESEARCH OBJECTIVES

The main objective of this research project is to utilize the statistical/artificial neural network approach for the development of appropriate SANN-based models to effectively project the full six-hour response from a shorter-duration permeability response. The aforementioned research objective will be accomplished through the following interrelated tasks:

Task 1: Database Development: All KDOT-documented Rapid Chloride Permeability tests performed during the past several years on various PCC sample types will be combined to build an extensive six-hour time-permeability response database. Best strategy to build the database will be decided upon after consultation with KDOT personnel.

[1] Personal communications with Dave Meggers (PE), Research Development Engineer, KDOT Bureau of Materials and Research.

Task 2: Network Training and Development: The database developed in Task I will be utilized in this task to develop appropriate SANN-based models that can effectively project the full six-hour response from a shorter-duration permeability response. Various models with varying measured response time will be developed. Therefore, the SANN approach will be employed to accurately capture and deduce the associations and patterns embodied within the measured six-hour time-permeability response data sets. In this regard, part of the available data sets will be used to develop/train the models while the remainder of the database will be used to validate the accuracy of the developed models. It is envisioned that efficient 0.5-hour, 1-hour, 1.5-hour, and 2-hour duration models can be developed via the SANN approach.

Task 3: Utilization: SANN-based permeability response prediction models, in the form of an excel-based software computer program, will be developed and tested so that it can be run on a PC. The developed software program will then be delivered to KDOT-project monitor.

IV. ESTIMATE OF FUNDING AND RESEARCH PERIOD

Research period: 18 months [Requested starting date: June 1, 2007].
Tentative funding request: $95,000

The funds will mainly cover costs of: i) acquiring software programs and computers needed to carry out the proposed tasks, ii) providing financial support for graduate student(s) involved in this research, iii) providing summer support for the research team, and iv) providing travel support for the research team. It is anticipated that the member of the research team will present their research outcomes at national and international conference(s), thus increasing the visibility of K-State in this area of research.

V. URGENCY AND PAYOFF POTENTIAL

Using the available permeability response database, appropriate SANN-based permeability response prediction models can be developed. The developed models would be used to efficiently project the full 6-hour coulomb-value permeability response. These models will allow KDOT to reduce the duration of the Rapid Chloride Permeability test from 6 hours to 1 or 2 hours. Additionally, these models will allow KDOT to i) increase the number of tests that can be performed in one day, and ii) minimize/eliminate damage to the testing cells, particularly when excessively permeable concrete is tested. The proposed research will provide an excellent research opportunity to produce innovative prediction models that will impact Chloride Permeability testing procedure for KDOT and other DOT agencies. Moreover, KDOT will most likely be the first in the nation to utilize the SANN approach to fully characterize the Chloride Permeability Testing Protocol, thus leading the nation, and most likely the world, in this endeavor.

VI. IMPLEMENTATION STRATEGY

The resulting models can be implemented as part of the laboratory testing program within KDOT's material unit. These models could be used by the KDOT material unit to efficiently project the full six-hour concrete permeability response from actual results taken from a corresponding shorter-duration Rapid Chloride Permeability test.

VII. PROJECT PERSONNEL

This project will be carried out under the direction of Dr. Yacoub Najjar (Principal Investigator) from the Department of Civil Engineering at Kansas State University. The study will be conducted with the aid of one graduate student and in full cooperation with KDOT personnel. Dr. Najjar has over nineteen years of teaching and research experience with transportation related projects. For the past thirteen years, Dr. Najjar has successfully applied the statistical/neural network approach to model various transportation material engineering systems. Dr. Najjar's areas of expertise related to this study are neural networks and numerical and statistical analysis of transportation engineering systems.

VIII. SUBMISSION INFORMATION

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