Calibration of the 2002 American Association of State and Highway Transportation Officials (AASHTO) Pavement Design Guide for Minnesota Portland Cement Concrete Pavements and Hot Mix Asphalt Pavements

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Under the National Cooperative Highway Research Programs (NCHRP) 1-37A study "Development of the 2002 Guide for Design of New and Established Pavement Structures" (2002 Guide). ERES Consultants (in conjunction with Furgo-BRE, Inc., the University of Maryland and Arizona State University) was awarded the contract to develop the 2002 Guide. The objective of this project is to develop and deliver the 2002 Guide and associated computational software for adoption and distribution by the American Association of State and Highway Transportation Officials (AASHTO).

The mechanistic-empirical performance prediction models in the 2002 design procedure were calibrated using nationwide pavement performance data. Although MnRoad performance data were actively used in calibration, it will be necessary to perform calibrations against wider range of Minnesota variables to achieve a practical procedure. It will also be necessary to evaluate the performance of in-service pavements to establish reasonable distress threshold criteria for use in the Guide.

This study will include development of guidelines for major input parameters (traffic, material properties, subgrade characterization), comprehensive sensitivity analysis, comparison against MnPave and current design standard, comparison of predicted pavement performance prediction models for local conditions.

Project Start: July 12, 2004 **Project End:** September 29, 2006

OBJECTIVE

The objective of this project is to improve guidelines for Minnesota asphalt and concrete pavements by adapting the latest mechanistic-empirical design procedure and calibrating it for local conditions.

SCOPE

The mechanistic-empirical 2002 Design Guide developed under the NCHRP 1-37A study will be adapted for design of concrete and asphalt pavements in Minnesota. A comprehensive evaluation of Minnesota site conditions (traffic, subgrade and climate) will be conducted and guidelines for appropriate inputs selection will be developed. Material testing of the typical construction materials (concrete and asphalt) will be performed and guidelines for selection of the material input parameters for all input levels will be provided. The performance thresholds applicable to Mn/DOT pavement standards will be selected and verification/validation analysis of the mechanistic-empirical distress prediction models will be performed. The key distress types will include AC cracking, AC rutting, thermal cracking, PCC joint faulting, PCC top-down slab cracking, PCC bottom-up slab cracking and roughness. The coefficients of performance prediction models will be modified to match predictions with the observed performance data. A catalog of recommended trial design features for typical site conditions (location and traffic) will be developed using 2002 Design Software with recalibrated models. Finally, the training materials developed under the NCHRP 1-37A study will be updated to better meet Mn/DOT needs.

WORK PLAN

Task 1: Determine Typical Design Deatures

The University will collect information on in-service Minnesota rigid and flexible pavements. The University will summarize the typical design features (pavement cross-section, presence of shoulder, land width, presence of dowels, etc.) for different types of pavements (interstate, state and county roads) and traffic levels. The University will collect information on expected design life, as well as on the actual pavement performance, by reviewing pavement performance data from MnRoad, LTPP and Mn/DOT pavement management databases. The University will contact neighboring states to obtain pavement performance data relevant to this study.

Since intensive cooperation with Mn/DOT is crucial for success of this task and the entire project, the research team will provide basic software training for the TAP members.

Task 2: Evaluate Typical 2002 Design Guide Inputs
The University will evaluate and compare the inputs of the 2002 Guide with available information on Minnesota pavements to establish default Level 3.

The University will specifically collect and analyze the following information:
- Available Equivalent Single Axle Load (ESAL) and axle spectrum data (from W-4 or WIM)
- Material properties of typical PCC mixes, asphalt mixes and granular bases
- Resilient properties of the subgrade
- Seasonal variation of subgrade properties
- Seasonal variation of depth to water table
- Climatic data
- PCC pavements construction data

The University will evaluate the material database for MnRoad construction materials and other sources of information and develop the experimental design for laboratory testing. The University will perform preliminary sensitivity analysis to evaluate relative significance of the design inputs.

Task 3: Conduct Laboratory Testing
The University will conduct laboratory testing of the typical construction materials (concrete and asphalt) used in Minnesota pavement construction using the test method adopted for 2002 Guide. The University will develop a database of material properties. The University will establish agency procedures for input, determine typical input values for use as Level 3 inputs and develop test protocols for obtaining Level 1 and Level 2 inputs. The University will measure the following properties under this task:
- PCC modulus of elasticity
- PCC coefficient of thermal expansion
- AC complex modulus
- AC tensile stress
- Subgrade resilient modulus

Task 4: Establish Performance Criteria
The University will evaluate the performance of in-service pavements and establish reasonable distress threshold criteria and reliability levels for use in the 2002 Guide.

The University will develop the set of acceptable pavement performance indicators (critical values of cracking, rutting, faulting, roughness, etc.) using the Mn/DOT Pavement Management System (PMS) database, as well as input from Mn/DOT's concrete and asphalt industry.

Task 5: Perform Sensitivity Runs
The University will perform sensitivity runs using the 2002 Design Software for typical Minnesota site conditions and a wide range of pavement design features (layer thickness, material properties, shoulder types, load transfer mechanisms, etc.). The University will rank the design input in order of their effect on predicted pavement performance and determine the level of detail actually required for the numerous inputs to the program performance prediction models. The University will evaluate if the predicted pavement performance falls within expected limits and if the performance trends (change in predicted performance with change in design features) are reasonable. The University will provide recommendations on additional laboratory testing and needs for the model recalibration.

Task 6: Predict Pavement Performance
The University will select a set of in-service pavement sections with known design parameters and performance. This will include MnRoad sections, sections from past research studies and sections identifies in this study. Using the 2002 Design Procedure distress prediction models (for cracking and faulting for PCC pavements and AC cracking, AC rutting, thermal cracking and roughness), the University will predict performance for these sections. The University should make predictions using input Level 2 and Level 3. The University will compare these predictions with observed field performance and identify major discrepancies and biases in prediction separately for Level 2 and Level 3.

Task 7: Recalibrate 2002 Design Prediction Models
The University will recalibrate the 2002 Guide distress prediction model, if necessary. This calibration may be desirable to eliminate bias and to reduce the error of prediction. If the error of prediction were reduced, the resulting designs at a given level of reliability would be more cost effective. It is expected that substantial recalibration of the International Roughness Index (IRI) prediction models will be required.

Task 8: Develop Catalog for Trial Designs
The University will perform runs of 2002 Design Software, using a selected set of model parameters, to create a catalog of recommended design features for trial design (first iteration) for typical site conditions (location and traffic). This catalog will not substitute actual design, but will provide a designer with a good starting point. The designer will use it to predict pavement performance for specific site conditions. If the performance criteria are not met, or if a design solution is shown to be too conservative, the designer will modify the solutions using recommendations developed under this task.

Task 9: Modify Training Manuals
The University will review and update the training materials (Power Point slides) developed under the NCHRP 1-37A study using the results of Tasks 1 through 8. The training materials will provide a bridge between the current design procedures used by Mn/DOT and the 2002 Design Procedure.

Task 10: Develop a Report Documenting the Work and Findings
The University will perform runs of the 2002 Design Software, using a selected set of model parameters, to create a catalog of recommended design features for trial design (first iteration) for typical site conditions (location and traffic).

Task 11: Final Report
The University will revise the final report per the technical and editorial review comments.