PAVEMENT PERFORMANCE DATA ANALYSIS FORUM

Sponsored by the TRB Data Analysis Working Group
Michael I. Darter, Chairman
A. Robert Raab, TRB Senior Program Officer

January 12, 2002
Blue Room, Omni Shoreham Hotel, Washington, DC

0900-0930am   Call to Order
                Chairman's Welcome
                Staff Report

0930-1000am   **DEVELOPMENT OF ANYTIME WEATHER SOFTWARE**
                Alaeddin Mohseni, Pavement Systems, Bethesda, Maryland

1000-1015am   Presenters' Questions

1015-1030am   Morning Break

1030-1100am   **A NINE YEAR EVALUATION OF THE FIELD CRACKING AND RUTTING
                PERFORMANCE OF THE SUPERPAVE SPS-9 PROJECTS**
                Leonnie Kavanagh, Manitoba Department of Transportation, Winnipeg, Manitoba,
                Canada

1100-1115am   Presenters' Questions

1115-1145am   **WEST VIRGINIA INSTRUMENTED CONCRETE PAVEMENT: CURING AND
                TEMPERATURE INDUCED STRAINS DURING THE FIRST 90 DAYS**
                Samir N. Shoukry, West Virginia University, Morgantown, West Virginia

1145-1200noon   Presenter's Questions

1200-0130pm   Mid-Day Break

0130-0200pm   **DEMONSTRATION OF DATAPAVE 3.0**
                Ewa Rodzik, Federal Highway Administration, Washington, DC

0200-0215pm   Presenter's Questions

0215-0245pm   **USING THE LTPP DATABASE TO COMPARE PREDICTED AND ACTUAL
                PAVEMENT PERFORMANCE**
                Norbert J. Delatte, Jr., The University of Alabama at Birmingham, Birmingham,
                Alabama

0245-0300pm	Presenter's Questions
0300-0330pm	**ANALYSIS OF PAVEMENT DETERIORATION IN QUEENSLAND, AUSTRALIA** Phil D. Hunt, Queensland Department of Main Roads, Roma, Queensland, Australia
0330-0345pm	Presenters' Questions
0345-0400pm	Afternoon Break
0400-0430pm	**UNDERSTANDING AASHTO AND ASTM STANDARDS FOR PAVEMENT DISTRESS SURVEY** Kelvin C.P. Wang, University of Arkansas, Fayetteville, Arkansas Jerry Daleiden, Fugro-BRE, Austin, Texas
0430-0445pm	Presenter's Questions
0445-0515pm	**INFLUENCE OF THE WATER CONTENT IN THE UNBOUND LAYER ON BEARING CAPACITY OF PAVEMENT** Darko Kokot, Bojan Leben, and Primoz Pavsic Slovenian National Building and Civil Engineering Institute, Ljubljana, Slovenia
0515-0530pm	Presenter's Questions
0530-0600pm	Steering Committee Session
0600pm	Close of Meeting

DEVELOPMENT OF ANYTIME WEATHER SOFTWARE

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ABSTRACT

The objective of this study is to provide instant access to Virtual Weather data. Virtual Weather data is a powerful tool for highway engineers and researchers since it provides the best estimates of climatic conditions at any location (project site) and any time (historical) in North America. Computed climatic parameters for various pavement design, construction, management, maintenance, and research purposes may be developed from Virtual Weather data.

Previous study showed that climatic estimates determined from five nearby weather stations (virtual weather) are reasonably good and within acceptable range. Therefore, it was concluded that representative climatic conditions at any location could be reasonably estimated.

Development of software is underway that provides substantially improved estimates of environmental conditions at a site almost instantly. In addition to extreme temperatures and precipitation, computed parameters such as Freezing Index and heat degree-days may be calculated. Climatic regions may be defined and shown on the map. Another application is developed for determining construction cut-of dates. A software tool also provides work-days calculations. Several selection routines are built to show regions with a certain climatic feature. Software may include many other applications that use climatic data (winter maintenance, etc.)

PRESENTER'S QUESTIONS: I would like to receive comments, suggestions, and feedback from the meeting's attendees on the following matters:

1. In what other ways Virtual Weather data can be used?

2. Are the software features adequate? What other features may be added?

PRESENTER'S STATEMENT: This work is still in progress, and has not been submitted for presentation or publication at another meeting.

A NINE YEAR EVALUATION OF THE FIELD CRACKING AND RUTTING PERFORMANCE OF THE SUPERPAVE SPS-9 PROJECTS

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ABSTRACT

Though the first of twenty-six Specific Pavement Studies SPS-9 experiments was built over 9 years ago, there have been no definitive report on the experiment's overall field performance. How well the Superpave SPS-9 experiment, designed to validate SHRP Superpave asphalt specification and mix design system, is performing in the field is therefore a frequently asked and, until recently, unanswered question.

This analysis therefore provides an evaluation of the field cracking and rutting performance of the SPS-9 experiment using the most recent and available Level E distress data from the LTPP Information Management System (IMS) database. In addition to the field evaluation, an analysis was conducted to determine whether a performance difference exists between the Superpave "correct" PG binder and the alternative PG binder within each of the SPS-9 projects, by relating distress trends through statistical means and variances (T-test and F-test) analysis. Field distresses included pavement rutting, fatigue cracking, longitudinal wheelpath and non-wheelpath cracking, and transverse cracking.

As background, four SPS-9 (Specific Pavement Studies) pilot projects were constructed in 1992, as part of the SHRP SPS experiments, to assess the field performance of the Superpave asphalt specification and mix design system. Since 1992, twenty-two additional projects have been built, for a total of 26 projects involving 18 States and 4 Provinces. Each project consisted of at least three test sections. One test section with an agency mix, a second section with a Superpave mix design using a PG binder selected at the 98% reliability criteria, and a third section with a Superpave mix using an alternative PG binder selected to exhibit early distress. The projects were either new asphalt pavements on new grade or asphalt overlays on existing asphalt or concrete pavements. On-going manual distress surveys and periodic automated photographic PADIAS distress surveys were conducted at each project since construction.

Prior to the first quarter of 2001, little SPS-9 field data existed in the LTPP IMS database for meaningful performance analysis. However a major effort was undertaken in 2001 to populate the IMS database with SPS-9 data. While this new data facilitated this performance analysis, a number of related issues arose. The comparison of manual and PADIAS distress surveys was found to have poor correlation (confirming the results of the "Study of LTPP Distress Data: Variability, Volume 1. FHWA-RD-99-074"), with distress data gaps still existing within the IMS database. Mix materials data as well as PG binder grade data were also not readily available for all projects in the database. Despite the gaps in the database, some interesting analysis results and observations have been found on the field performance of the SPS-9 experiment.

This presentation will present the findings of the analysis and seek comments and discussions on how best to address missing data in the experimental database.

PRESENTER'S QUESTIONS: I would like to receive comments, suggestions, and feedback from the meeting's attendees on the following matters:

1. Distress comparisons were made for all projects in the SPS-9 experiment based on the most recent distress survey for each project. Since the most recent survey does not occur in a same year for each project, is an experiment-wide distress comparison based on the most recent survey valid?

2. Both manual distress survey and limited PADIAS automated distress survey were conducted, but have been found to have poor correlation. How best to integrate the distress data from the two methods to fill missing timeline gaps in the database?

PRESENTER'S STATEMENT: This work is still in progress, and has not been submitted for presentation or publication at another meeting.

WEST VIRGINIA INSTRUMENTED CONCRETE PAVEMENT: CURING AND TEMPERATURE INDUCED STRAINS DURING THE FIRST 90 DAYS

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ABSTRACT

A 450 ft. long section of a newly constructed highway near Elkins, West Virginia (Corridor H) was instrumented using a variety of sensors to monitor the response of concrete slabs to environmental effects. The 2-lane pavement section consists of 11 in. thick and 15 ft long dowel jointed concrete slabs with tied shoulders placed on 4 in. thick asphalt-stabilized free-drainage base. Before the placement of concrete, a layer of sand was placed on the top of the base layer (at the locations of instrumented slabs) to reduce slab-base friction. Low modulus vibrating wire strain gauges were placed at a depth of 1.5 in. from the slab top and 1.5 in. from the slab bottom along seven points on the longitudinal slab centerline and 5 points along the transverse slab centerline. The low-modulus gauges are used to capture the long-term build up of slab strain due to curing and the subsequent changes in the strain due to environmental effects. Concrete embedment wire-resistance strain gauges are placed 1 in from the slab bottom to monitor the dynamic strain due to traffic. Data collection from the sensors started few minutes before the placement of concrete at a rate of 6 samples per hour and continued at this rate during the first seven days, after which the sampling rate was dropped to 3 samples per hour. Thus, the strain profile on top and bottom of the slab, the longitudinal and transverse joint openings, the temperature gradient profile in the slab, as well as the bending moment and axial force developed in the first (shoulder), third, sixth, and twelfth dowels are continuously recorded at the aforementioned rates. The signals from 99 percent of the sensors were found to be free from electronic noise; the data are being collected and analyzed without the introduction of any electronic or digital filters. Since one of the many objectives of this project is to provide quality data that can be used to validate Finite Element Model predictions of concrete slab response to thermal effects, the measured strain profile due temperature gradient should be extracted from the total measured strain. The analysis of the strain data that will be presented indicate that the placement of 10 ft. wide tied shoulder resulted in a noticeable increase in the tensile strain in the slab as well as the bending moment in the dowel closest to the shoulder.

PRESENTER'S QUESTIONS: I would like to receive comments, suggestions, and feedback from the meeting's attendees on the following matters:

1. How can the strain-time history due to changes in thermal gradient be extracted from the total measured strain?

2. The measured transverse strain in the slab is not symmetric about the longitudinal slab centerline. Is this due to the construction technique or the timing of sawing the longitudinal joint?

3. What is the effect of a tied shoulder on slab strain?

4. Are there other field measurements of the strain distribution (in full size concrete slabs) that could be used for comparison with the Elkins data?

5. Considering the unavoidable simplification in computer models (e.g. FEM), which measured quantities are best suited for validation of the model response to temperature variations?

PRESENTER'S STATEMENT: This work is still in progress, and has not been submitted for presentation or publication at another meeting.

DEMONSTRATION OF DATAPAVE 3.0

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ABSTRACT

Demonstration of the recently released software used for extracting and analyzing pavement performance data collected as part of the Long Term Pavement Performance (LTPP) program.

The primary objective of DataPave is to provide a user-friendly format for exploring, extracting, and organizing LTPP information. A secondary objective has been to provide mid- and upper-level management and other users with quick, easy-to-use presentations to illustrate the value and potential of LTPP data. To meet both objectives, DataPave contains a series of modules that allow easy viewing of time sequence pavement performance data and the capability to browse, retrieve, and save LTPP information in a convenient format. DataPave 3.0, the current version, improves the DataPave 2.0 software and incorporates the latest IMS database.

The enhancements of the program include two aspects: inclusion of considerably more LTPP data and improvements or additions to the program functionality.

The data contained in this version of DataPave were obtained from LTPP IMS database release 11.5 (Version NT3.0) in June 2001. Considerably more data are available in DataPave 3.0. The total number of records has increased by about 40% compared to DataPave2.0. The number of regular LTPP section and construction event records at QC Level E in EXPERIMENT_SECTION table has increased by about 33% (from 2771 sections to 3686 sections).

Only minor program improvements and bugs fixing were performed for DataPave 3.0 version. The following is a list of the new and improved functionality in DataPave 3.0:

- Section Selection Module – The selection filter ranges are modified to be upper bound exclusive. For example, if you select ADTT of 100 as the Low bound and 1000 as the High bound, then only sections with ADTT from 100 to 999 will be selected (i.e. 100 =ADTT<1000). This rule applies to the pavement surface thickness, freezing index, and annual precipitation filters as well.

- Chart Trend and Section Presentation Modules – Notes are added to the graphs where computed data, instead of the raw LTPP IMS data, are graphed.

- DataPave Exploration and Extraction Module – A bug was fixed so that whenever a data element in an IMS table is selected, all the key data elements are also selected simultaneously.

- DataPave Exploration and Extraction Module – The program was enhanced to extract site-specific records from both AWS and CLM module tables. Note that when AWS_* tables are extracted from the DataPave CD-ROM, the AWS_LINK table should also be extracted and used to link other AWS_* tables to the State_Code and SHRP_ID of the site. Similarly, when CLM_* tables are extracted, the CLM_SITE_VWS_LINK table should also be extracted and used to link other CLM_* tables to the State_Code and SHRP_ID of the site.

PRESENTER'S QUESTIONS: I would like to receive comments, suggestions, and feedback from the meeting's attendees on the following matters:

1. Based on the presentation or prior knowledge of DataPave, how can the attendees envision using DataPave?

2. What are the best ways to encourage use of LTPP data/DataPave by State DOT engineers?

3. What suggestions do the attendees have for how DataPave can be improved in the future?

PRESENTER'S STATEMENT: This work is still in progress, and has not been submitted for presentation or publication at another meeting.

USING THE LTPP DATABASE TO COMPARE PREDICTED AND ACTUAL PAVEMENT
PERFORMANCE

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ABSTRACT

The AASHTO 1993 Design Guide provides equations that may be used to predict pavement performance over time, relating cumulative traffic (in ESALs) to changes in serviceability. The LTPP Database, through DataPave 3.0 software, provides information on actual pavement performance over time. In this presentation, direct comparisons are made between AASHTO and other design models and actual documented pavement performance. The layer thickness and material property information from the database are used to develop the inputs for the 1993 AASHTO equations, to develop plots of traffic versus serviceability. Actual pavement performance is developed from the database through at two-step process. The International Roughness Index may be obtained for a number of dates from the database – usually three or four dates are available. IRI may be converted to serviceability. Next, the cumulative traffic for those dates, in ESALs, is estimated using the database information.

This initial analysis provides a comparison between predicted and actual performance, and further analysis is possible from this point. Comparing observed field performance to design predictions makes it possible to address the following questions:
- What assumptions need to be made to apply the design procedures?
- Does the field performance closely track the design procedure, or does the procedure overpredict or underpredict performance?
- If several design procedures are available, which provides the best prediction?
- Are there any significant factors that appear to affect performance that are not accounted for in the available design procedures?

This presentation will include a discussion of how the LTPP database may be accessed through DataPave 3.0 software, an example of an analysis that may be conducted, and some sample results. DataPave 3.0 software makes it possible for a large number of users to access decades of pavement performance information for a wide variety of designs, traffic levels, and environmental conditions. The presenter is particularly interested in audience input as to how this procedure may be improved and refined, what alternate approaches are available for comparison and the further investigations that may be made on the basis of the performance comparisons.

PRESENTER'S QUESTIONS: I would like to receive comments, suggestions, and feedback from the meeting's attendees on the following matters:

1. What is the best way to use DataPave 3.0 to develop design inputs for flexible pavement material properties? Specifically, what is the best way to characterize the resilient modulus, among other parameters?

2. What is the best way to use DataPave 3.0 to develop design inputs for flexible pavement material properties? Specifically, what is the best way to characterize modulus of subgrade reaction, among other parameters?

3. What are different ways to estimate cumulative traffic and the associated pavement serviceability using DataPave 3.0.

PRESENTER'S STATEMENT: This work is still in progress, and has not been submitted for presentation or publication at another meeting.

ANALYSIS OF PAVEMENT DETERIORATION IN QUEENSLAND, AUSTRALIA

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ABSTRACT

Queensland's State and National Highway Road system has a replacement value of $23 billion, excluding bridges. Pavement management systems are used to assist engineers in the management of these large assets and aid in the recording, rating, and prediction of a pavement's condition, which in turn assists in prudent and sophisticated management of the road network. One of the fundamental components of a pavement management system is the method of determining a pavement's rate of deterioration over time. Throughout the world, pavement roughness is one of the most widely used methods of measuring the performance of a pavement and is subsequently the primary focus of this research.

Queensland is a large State consisting of many small communities separated by vast distances. Therefore, the majority of bitumen sealed pavements exist in rural areas, and consist of either a flexible unbound granular pavement or a semi-rigid modified granular pavement. This project has concentrated its investigation on the roughness progression of these pavement types.

Traditionally, roughness progression with time has been represented in many asset management models as an exponential relationship, providing rapidly increasing roughness values as the pavement approaches the end of its theoretical life. However, this relationship is not commonly observed in pavements throughout Queensland. Therefore, in order to further understand the roughness progression behaviour of pavements, this research has considered some 16,000 pavement segments from all parts of the State. The number of pavement segments studied is considered significant, as many previous research efforts which form the basis of the current roughness progression models, have only been based on the study of anywhere between forty and several hundred pavement segments.

Roughness data collected since 1987, at varying frequencies around the State of Queensland, has been used to investigate trends in the progression of roughness over time (ΔR). Subsequent to the calculation of ΔR, regression of ΔR against many independent variables commonly used in the management of roads, analysis of the affect of pavement maintenance costs ΔPMC, rating pavement condition using a combination of ΔR and ΔPMC, and distribution analysis of pavement condition for many independent variables, has been investigated in an attempt to better understand the principles and behaviour of pavement deterioration.

The presentation to the DAWG forum will focus on the methods used to extract, manipulate, calculate and analyse approximately 60 million pavement condition data records, and display the subsequent findings.

PRESENTER'S QUESTIONS: I would like to receive comments, suggestions, and feedback from the meeting's attendees on the following matters:

1. Has a linear representation of roughness progression been used in other research works or in the asset management of road networks by road agencies? If no, what is your experience? Is there any comment pertaining to the measure of accuracy (MAE) used in this work?
2. This research has proposed one method of taking into account the effect of Pavement Maintenance Costs on Roughness Progression, are there any other methods currently used in road management that may enhance this work?

3. Is the method of identifying 'Network Performance' considered useful?

PRESENTER'S STATEMENT: This work is still in progress, and has not been submitted for presentation or publication at another meeting.

UNDERSTANDING AASHTO AND ASTM STANDARDS FOR PAVEMENT DISTRESS SURVEY

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ABSTRACT

Recently, there have been two major efforts by American Association of State Highway and Transportation Officials (AASHTO) and American Society of Testing Materials (ASTM) to standardize the collection and analysis of pavement surface distresses, particularly pavement cracks. This presentation discusses the authors' interpretation of the two efforts and their ramifications.

Standard Practice for Quantifying Cracks in Asphalt Pavement Surface, AASHTO designation PP44-00, is a guideline for highway agencies to establish cracking classifications. There was not an industry standard on pavement cracking indexing. Many highway agencies are using the LTPP distress manual published in 1993 or it derivations as guidelines. The new AASHTO PP44-00 uses much simplified approach to classifying cracks. In particular, PP44-00 divides pavement geometrically into wheel-path areas and non-wheel-path areas, therefore distinguishing load associated cracks from non-load associated cracks. In addition, there are three severity levels based on width of cracks. The intensity is defined as the total length of cracking per unit area (m/m^2) for each defined survey strip. Each highway agency may also introduce additional requirements, such as edge cracking and transverse cracking.

PP44-00 provides a very robust scheme to identify load associated cracks, and at the same time, not go to extraordinary details about types of cracks. This simplicity lends itself very well to be used in automated devices for distress survey. The Standard Guide for Classification of Automated Pavement Condition Survey Equipment, ASTM designation E 1656-94, is the guide that would implement PP44-00 into algorithms of an automated device. Even though ASTM E 1656-94 addresses longitudinal and transverse profiling, the portion on Equipment Capability-Measuring Cracking of Pavement Surfaces is important in classifying equipment based on resolution and other features for specialty automated devices for pavement cracking survey.

After reviewing the key points of both standards and their potential applications, the authors will also discuss the needs of highway agencies and industry vendors, particularly on the issue of using automated systems, their calibration, accuracy, and technical challenges, such as computer storage.

PRESENTERS' QUESTIONS: I would like to receive comments, suggestions, and feedback from the meeting's attendees on the following matters:

1. Are there similar standards in Europe and Japan?

2. What would be the absolute minimum resolution on pavement surface for automated device from the point of view of a state highway pavement management engineer?

3. Is it time again to use on-the-fly technology to collect and process cracking data? There were several major efforts in the last 20 years and each of them either failed or has limited applicability.

PRESENTERS' STATEMENT: This work is still in progress, and has not been submitted for presentation or publication at another meeting.

INFLUENCE OF THE WATER CONTENT IN THE UNBOUND LAYER ON BEARING CAPACITY OF PAVEMENT

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ABSTRACT

Test section on the motorway was used for preliminary measurements of the moisture content in the unbound layer (crushed limestone material). The pavement structure on the test section is: 19 cm of asphalt layers, 16 cm of unbound material and 25 cm of cement stabilized gravel (CS). According to our practice, this is a special construction, where the CS layer is placed under the unbound one. The main reason why we started with this work is to check the quality of the unbound layer showing a slight deviation from the criteria used for materials, built in the construction.

TRIME - Time Domain Reflectometry with Intelligent Micromodule Elements were built in the unbound layer and on the top of the CS layer. The TRIME method is the TDR - Time Domain Reflectometry technique that makes possible to measure volumetric and gravimetric moisture content of materials. Beside this we are collecting the temperature data of the layer, where the TRIME elements are installed. The amount of precipitation and air temperature is also collected.

The analysis of the results begins with converting the measured data in mA to volumetric moisture content from which gravimetric moisture content is calculated.

We performed the measurements of the bearing capacity with FWD and Lacroix deflectograph in 4 cycles, considering the periods with less and more precipitations.

Now we are in the middle of the project. The first conclusions of the analysis of the data gathered in one year time are quite different from those expected.

The level of the moisture in the unbound layer is from 4,5 mass % to 8 mass % and it is changing with the amount of the precipitations. After the rain, the level of the moisture decreases in a very short time.

The bearing capacity is on the expected level all the time, where the minimum and maximum deflections vary for about 20%.

The backcalculation of the modulus is based on the ELMOD program. The moduli of the unbound layer were obtained from the measurements on the overtaking lane beside the test section, where the pavement structure is asphalt over unbound layer (without the CS layer), and using two-layer model. After that we defined the ratio of the modulus of unbound and CS layer, which we used in backcalculation in the three layer model. That gave us module for the unbound layer and the CS layer for the pavement in the test section. The results are in the expected range. Oscilations of the modulus of all layers are showing similar distribution.

Quality deviations of the unbound material may be a reason for not good functional characteristics of the overall pavement performance, where we must take into consideration that motorway construction was without any traffic in the research period. The temporary results are not showing significant confirmations of this statement at the test section observed in this project.

PRESENTERS' QUESTIONS: We would like to receive comments, suggestions, and feedback from the meeting's attendees on the following matters:

1. What do you think about the analysis procedure used for determining the modulus of the unbound and CS layers?

2. What do you think about the moisture content levels measured in the unbound layer, knowing that the optimal moisture content of this material determined in laboratory is 4.2%?

3. The measurements with FWD showed the difference of 20% in min and max deflection. Is the difference reasonable, knowing that there was no traffic on the test section during the measurements?

4. We examined the correlation between the rainfalls and the content of the moisture in the unbound layer. We found out that the largest influence of the precipitation on the moisture content is two days after the falls. What is your comment?

PRESENTERS' STATEMENT: This work is still in progress, and has not been submitted for presentation or publication at another meeting.