

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 11, 2003

Blue Room, Omni Shoreham Hotel, Washington, DC

0900-0930am	Call to Order Chairman's Welcome Staff Report
0930-1000am	DAMAGE BASED PERFORMANCE GRADE FOR AC BINDERS Alaeddin Mohseni Bethesda, Maryland, USA
1000-1015am	Presenters' Questions and General Discussion
1015-1030am	Morning Break
1030-1100am	MODELLING THE VARIABILITY IN THE SWEDISH LTPP-DATA Fridtjof Thomas Borlänge, Sweden
1100-1115am	Presenters' Questions and General Discussion
1115-1145am	EFFECT OF SEASONAL VARIATIONS ON PAVEMENT LAYERS' MODULI* Hassan M. Salem Moscow, Idaho, USA
1145-1200noon	Presenter's Questions and General Discussion
1200-0130pm	Mid-Day Break
0130-0200pm	LTPP TRAFFIC AND LOADING DATA VARIATION AND ITS INFLUENCE ON PAVEMENT PERFORMANCE MODELING* Yuhong Wang Lexington, Kentucky, USA
0200-0215pm	Presenter's Questions and General Discussion

0215-0245pm	APPLICATION OF AASHTO INTERIM DISTRESS PROTOCOL TO AUTOMATED PAVEMENT DISTRESS SURVEY Kelvin C.P. Wang Fayetteville, Arkansas, USA
0245-0300pm	Presenter's Questions and General Discussion
0300-0330pm	DAMPING EFFECTS ON DYNAMIC ANALYSIS OF FWD DATA Sergio Garza and Waheed Uddin University, Mississippi, USA
0330-0345pm	Presenters' Questions and General Discussion
0345-0400pm	Afternoon Break
0400-0430pm	APPLICATION OF HILBERT-HUANG TRANSFORM TO PAVEMENT PROFILES ANALYSIS Nii O. Attoh-Okine Newark, Delaware, USA
0430-0445pm	Presenter's Questions and General Discussion
0445-0515pm	NEW VERSION OF LTPPBIND SOFTWARE FOR PG BINDER SELECTION Monte Symons Olympia Fields, Illinois, USA
0515-0530pm	Presenter's Questions and General Discussion
0530-0600pm	Steering Committee Session
0600pm	Close of Meeting

* This presentation is extracted from the author's submission to the Third International Contest on LTPP Data Analysis, which shared the first prize.

A NOTE ABOUT THE DAWG

The DAWG is an international forum for the discussion of methods of analysis of pavement performance data. Presentations at DAWG-sponsored forums address the technical interests of professionals engaged in highway research and engineering design, maintenance, and rehabilitation who are engaged in collecting, processing, and analyzing such data and developing insights into the behavior of pavements. Presentations offered by forum attendees (by prior arrangement) focus on work-in-progress concerning the development of techniques for extracting and analyzing data, and early results of recent applications of these techniques. Topics such as model building, sensitivity analysis, and development of transfer functions linking structural response to distress are especially popular and welcome.

A DAWG-sponsored forum has a minimum of formality to encourage open discussion among attendees and minimize the time between the presenters' preparation and dissemination of analytical results. The agenda is prepared in advance, based on responses to a call for abstracts. Abstracts are reviewed solely for conformity with DAWG guidelines, and as many as time permits are placed on the agenda. Presentations are not subjected to prior technical review. Copies of presentation materials are not distributed. Presentations are not published. Comments by forum attendees are not recorded.

DAWG-sponsored forums are held twice each year: immediately preceding the TRB Annual Meeting in Washington DC in January, and approximately at the midyear at another location. The midyear meeting is usually held in conjunction with a major highway pavement conference where it is expected that many attendees will also be interested in participating in a DAWG forum. If requested by the organizers, the DAWG will arrange and conduct a formal paper session conforming to all the policies and procedures of the conference.

As a TRB committee, the DAWG has appointed members who serve as a steering committee to guide the planning of future meetings. However, DAWG forums are open to everyone interested in the subjects to be discussed, and all attendees enjoy equal status. There is no registration requirement or fee required to attend meetings, but advance notice of the intent to attend a particular forum is recommended and appreciated.

Inquiries are welcome from those interested in adding their names to the DAWG's mailing list, and those wishing to submit abstracts of presentations for consideration for presentation at a particular forum. Inquiries and abstracts should be directed to:

Dr. A. Robert Raab, NA-443
Transportation Research Board
500 Fifth Street NW
Washington, DC 20001
Telephone: 202-334-2569
Fax: 202-334-3471
Email: rraab@nas.edu

PRESENTATION ABSTRACT FORM

Pavement Performance Data Analysis Forum

TRB Data Analysis Working Group

TITLE OF PRESENTATION:

ABSTRACT:

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

1-

2-

3-

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

Name:

Title and Organizational Affiliation:

Mailing Address:

Telephone/Fax/Email:

GUIDELINES FOR PREPARATION OF ABSTRACTS AND BRIEFINGS
FOR PRESENTATION AT PAVEMENT PERFORMANCE DATA ANALYSIS FORUMS
SPONSORED BY TRB'S DATA ANALYSIS WORKING GROUP (DAWG)

1. Presentations at DAWG Forums are selected through the review and evaluation of completed abstract forms submitted in response to calls for abstracts.
2. Only abstracts describing work in progress will be accepted for presentation. Completed work that has been submitted for presentation or publication elsewhere will not be accepted.
3. Presentations should focus on techniques for collecting, processing, and analyzing pavement performance databases, as well as preliminary results of applications of these techniques.
4. In addition to submitting an abstract of the proposed presentation, the presenter must complete the abstract form by also supplying a set of questions for attendees' discussion and response during the Forum. These questions should address issues being considered or confronted by the presenter in the further development of his/her project.
5. The technical quality of the abstract and the questions will be evaluated separately, and will have equal value in the determination of appropriateness of the submission for presentation.
6. The presenter will have 30 minutes for presentation of material (including interruptions by attendees seeking clarification) and an additional 15 minutes for a dialog with attendees concerning the Questions provided.
7. It is recommended that the presenter prepare a 20-minute presentation consisting of approximately 10-15 overhead transparencies. It is unlikely that the presenter will be able to present a higher number of transparencies in the time allotted. Projection equipment for overhead transparencies will be provided. Computer projection equipment will not be provided.
8. Time will be monitored closely. The presenter will be advised when his/her time is exhausted.

DAMAGE BASED PERFORMANCE GRADE FOR AC BINDERS

Alaeddin Mohseni, Ph.D., P.E.

Vice President, Pavement Systems

6105 Maiden Lane

Bethesda, MD 20817, USA

Telephone: 301-320-8680, Fax: 301-320-8681, Email: Ala_Mohseni@Yahoo.Com

ABSTRACT:

The objective of this study is to develop enhanced high-temperature performance grade (PG) selection algorithm for SUPERPAVE. The algorithm is being verified, adjusted and will be implemented into a new version of existing computer program.

The development of the enhanced high temperature PG algorithm is based on a rutting damage model using NCHRP 1-37A's AC permanent deformation model. Hourly pavement temperatures were calculated for 260 sites throughout the U.S. for a 20-year period. Pavement temperature frequencies were used in conjunction with the damage model to calculate the Performance Grade (PG) that limits rutting to the desired level. The rutting level is user-defined to allow agencies specify their target value.

The preliminary results indicate that the damage based PG typically proposes similar PG than exiting SHRP procedure up to grade of 58. At higher PG, however, damaged-based PG was typically one to two grades higher than SHRP. This is due to the longer extent of the heat period in Southern U.S. that SHRP procedure does not consider.

The new damage-based PG is developed for a standard level of traffic and highway speed. To adjust the PG for traffic levels higher than standard, Performance Grades have to be adjusted (Grade Bumping). As a part of this project, new grade bumping values were calculated using the damage-based procedure.

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

- 1- What level of rutting is more appropriate to use?
- 2- Can reliability be expressed in terms of target rutting level?
- 3- Is there any other parameter besides Degree-Days that may correlate with PG?

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

MODELLING THE VARIABILITY IN THE SWEDISH LTPP-DATA

Fridtjof Thomas, Ph.D. (Statistics)

The Swedish National Road and Transport Research Institute (VTI)

Box 760

SE-781 27 Borlänge, Sweden

Telephone: +46 243 736 75; Fax: +46 243 736 71; Email: fridtjof.thomas@vti.se

ABSTRACT:

How accurate can predictions for IRI, rutting, and cracking be? LTPP-data is one of the best controlled data available for building deterioration models which fit real traffic environments. Nevertheless, even the road sections purposely selected to be homogeneous with respect to all relevant criteria may exhibit very different deterioration rates. The variability of these LTPP-sections is a lower bound for the accuracy reasonably achievable by other deterioration models which are to be estimated from less accurate data, like the profiling measurements obtained for an entire road network. Understanding the variability of the in reality exhibited deterioration rates for road sections is essential for building models which describe the future state of a road in an adequate way. The Swedish LTPP-data is analysed for this variability, and a Bayesian dynamic linear model is presented which allows assessing the short-term prediction accuracy in road deterioration forecasts. Furthermore, a model structure is described which amalgamates mechanistically-based performance models with the stochastic approach for the short-term forecasts. It is argued that the structure of long-term prediction models should be derived from engineering knowledge, and that coherent statistical methodology is to be used for gradually adjusting these models to the evidence from the obtained measurements.

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

- 1- Evaluation of the prediction model: We should evaluate the predictive power of a model by contrasting it with some simplistic forecasts derived from a baseline model. But what is a reasonable yet simple model for that purpose in our context?
- 2- Model uncertainty is unavoidable, but should we account for that by using predictions from different models or should we formally conduct model-averaging for predictive purposes? Should we build one "super-model" which allows for different functional relationships? Which experience is available with formal model-averaging?
- 3- Communication of predictive uncertainty: The uncertainty in the predictions should be communicated to the practitioner. But if we forecast simultaneously several measures of performance and/or produce forecasts for several time periods, there is no simple representation which exhaustively describes the resulting multidimensional forecasting distribution. Which aspects of such a distribution are of most value to the practitioner?

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

EFFECT OF SEASONAL VARIATIONS ON PAVEMENT LAYERS' MODULI

Hassan M. Salem
Graduate Student
Department of Civil Engineering
University of Idaho
Moscow, ID 83844-1022
Telephone: 208-885-6818, Fax: 208-885-6608, email: hassan@uidaho.edu

ABSTRACT:

It is well known that seasonal variations have severe effects on pavement performance. While a soil or untreated pavement layer is more sensitive to moisture variation, an asphalt layer would be more affected by the change in temperature. The main goal of this research is to develop regression models that can enable design engineers to assess the seasonal changes in both subgrade soil and asphalt concrete (AC) layer modulus, and to develop an algorithm for calculating a seasonal adjustment factor (SAF) that allows estimating the layer modulus at any season from a known reference value. The study is based on analyzing data collected at the long-term pavement performance (LTPP) sites. The data is downloaded for seven different sites from the latest LTPP DataPave 3.0 software. The downloaded data included the backcalculated modulus for both subgrade soil and AC layer, AC surface temperature, subgrade soil moisture content versus time. The subgrade soil properties such as sieve analysis and atterberge limits are also downloaded.

The subgrade soil data were analyzed to establish the effect of subgrade moisture variation on subgrade's resilient strength represented by the backcalculated elastic modulus. Two regression models were developed to relate the variation in modulus with the variation in soil moisture content at various seasons. These models incorporate soil properties such as the plasticity index, percent fines as indicated by percent passing sieve # 200, and soil particle size for 60% passing, D60. A model for determining the SAF was also developed.

For the purpose of studying the effect of temperature variation on AC layer modulus, relationships relating the AC layer elastic modulus and the pavement surface temperature to the different months of the year were developed. Similar relationship relating the AC elastic modulus to the pavement surface temperature was also developed. Finally, it is intended to develop regression models to calculate the seasonal adjustment factor of the AC modulus at various seasons to allow estimating the layer modulus at any season from a known reference value.

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

- 1- How can I get the asphalt binder PG-grading for the selected pavement sections to include the effect of binder type on modulus-temperature susceptibility?
- 2- Based on the presented data, do you think that pavement surface temperature, measured through FWD test, is a good representative for AC layer temperature? Since I could not find information about the mid-depth AC layer temperature at the time of FWD testing.
- 3- Do you think that there are still more important parameters that could be added to the models? If so, what are these parameters?

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

LTPP TRAFFIC AND LOADING DATA VARIATION AND ITS INFLUENCE ON PAVEMENT PERFORMANCE MODELING

Yuhong Wang
Ph.D. Student
Department of Civil Engineering
University of Kentucky
Lexington, KY 40506-0281
Telephone: 859-323-3680, email: ywang1@engr.uky.edu

ABSTRACT:

Traffic and loading is the most important influencing factor on pavement performance. In the mechanistic-empirical pavement design procedures, as proposed by the 2002 design method, both loading and repetitions are required. In the traditional ASSHTO pavement design method, the number of estimated 18 kip cumulative Equivalent Single Axle Loads (ESALs) is a necessary input. In developing load-related distress prediction models, traffic and loading also plays a crucial role.

Over the years, the LTPP program has collected a large amount of traffic and loading data, which includes traffic volumes, truck volumes, and loads, etc. ESALs have also been calculated based on monitored traffic data or estimated based on historical data. These data were processed and then stored in two sources: the Central Traffic Database (CTDB) and the LTPP Information Management System (IMS).

Because the collection of traffic data in the field has been the responsibility of participating agencies, and because of traffic data's massive nature and complicated collection process, traffic data has shown large variations in many LTPP sites, even conflicting trends between historical data and monitored data. Both new design method and performance prediction models, however, require reliable traffic data to calibrate or validate the models. In addition, the projection of traffic data is necessary in pavement design and pavement management. Therefore, appropriate techniques should be employed to handle the large variations in LTPP traffic data, to replace missing data, and to help people gain knowledge on traffic projection.

This presentation will demonstrate the researcher's processing and analysis approaches on traffic data in the LTPP IMS, which includes reorganizing and preprocessing traffic data, replacing missing values, identifying variations, and investigating patterns of load spectrum. The implication of the variations and patterns on pavement design and pavement performance prediction will also be presented. Problems encountered by the researcher in analyzing traffic data will be reported at the end of the presentation.

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

- 1- How to solve the conflicting trends between historical traffic data and monitored traffic data (examples will be reported)?
- 2- How to handle large variations in traffic data (examples will be reported)?
- 3- How to solve the long tail problem in the traffic load spectrum data (examples will be reported)?

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

APPLICATION OF AASHTO INTERIM DISTRESS PROTOCOL TO AUTOMATED PAVEMENT DISTRESS SURVEY

Kelvin C.P. Wang
4190 Bell Engineering
Civil Engineering
University of Arkansas
Fayetteville, AR 72701
Telephone: 479-575-8425, Fax: 479-575-7168, email: kcw@engr.uark.edu

ABSTRACT:

The Arkansas State Highway and Transportation Department (AHTD) contracted the University of Arkansas to conduct a network crack survey of a large portion of its non-interstate National Highway System (NHS). The Digital Highway Data Vehicle (DHDV) was used to acquire high-resolution digital images and analyze cracks with the automated real-time Distress Analyzer. This presentation includes a preliminary study using the DHDV and the Distress Analyzer for data analysis on a network of about 100 miles of pavements. In addition, a manual survey was conducted on the same network of pavements. The data analysis with the Distress Analyzer covers the entire network, while the manual survey covers 5% of the same area on a mile-by-mile basis. Three distress protocols were studied in the data analysis: the AASHTO Interim Distress Protocol, the Texas DOT Method, and World Bank's Universal Cracking Indicator (CI). Particularly, the presentation will show the data analysis based on the CI method and the AASHTO Interim Distress Protocol. The study demonstrates that the automated real-time Distress Analyzer is effective in speed and accuracy. Because the Distress Analyzer is fully automated and results of the analysis are provided simultaneously to image collection, the potential large cost savings can be realized when compared with manual survey methods and other semi-automated survey technologies. The study also reveals that image quality is a critical factor for the Distress Analyzer.

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

- 1- Is the AASHTO Interim Distress Protocol detail enough for network level survey?
- 2- Is a State PMS engineer willing to archive images of an entire pavement network in computer storage?
- 3- What is the generally accepted minimum crack width used in State DOTs?

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

DAMPING EFFECTS ON DYNAMIC ANALYSIS OF FWD DATA

Sergio Garza¹ and Waheed Uddin²

¹Graduate Student

²Associate Professor

Department of Civil Engineering

The University of Mississippi

University, MS 38677

Telephone: 662-915 5363, Fax: 662-915 5523, Email: cvuddin@olemiss.edu

ABSTRACT:

The UMPED static linear elastic analysis program is used to backcalculate the in situ modulus values for asphalt pavement sections, considering FWD deflection data conducted for a project sponsored by the Mississippi DOT. The US45N Section 1, Station 461+05, is analyzed in this study. The in situ modulus values for this asphalt pavement are validated by the LS-DYNA three dimensional-finite element (3D-FE) dynamic analysis without damping. Different approaches for considering damping forces are discussed. The effect of 5 % damping ratio on the pavement response (deflections and vertical compressive stresses) and on the in situ backcalculated modulus values is investigated. The calculated deflections from LS-DYNA dynamic analysis considering each type of damping are compared to the measured FWD deflections.

The dynamic analysis results, considering system damping and Rayleigh damping, show smaller peak deflections in the range of 2 – 12 %. However, practically negligible differences in the vertical stress are calculated for the dynamic analysis considering both system damping and Rayleigh damping, compared to the dynamic analysis without damping. The backcalculated modulus values of the subbase and subgrade layer used for dynamic analysis without damping are slightly conservative (smaller than expected considering damping analysis). This demonstrates the reasonableness of the approach of conducting FWD dynamic analysis without damping. Further study is underway to investigate damping effects of 3D-FE dynamic analysis of wheel load pulses.

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

- 1- Does 5 % damping ratio considered in this analysis represent the field conditions for asphalt pavements?
- 2- Is it reasonable to consider the same damping coefficients for the different material layers in the pavement section?
- 3- Which approach is the best for considering damping in a dynamic analysis, system damping (damping matrix proportional to mass matrix) or Rayleigh damping (damping matrix proportional to mass and stiffness matrices)?
- 4- Does the load pulse duration affect the calculated deflections when considering damping?

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

APPLICATION OF HILBERT-HUANG TRANSFORM TO PAVEMENT PROFILES ANALYSIS

Dr. Nii O. Attah-Okine

Assistant Professor

Department of Civil and Environmental Engineering

University of Delaware

Newark DE 19716

Telephone: 302-831-4532, Fax: 302-831-3640, email: okine@ce.udel.edu

ABSTRACT:

The paper uses Hilbert-Huang transform (HHT) to analyze the road surface profile of two flexible pavements which are in varying conditions. The road profile is most fundamental excitation variable characterization and proper analysis of it is of utmost importance. It is also used in the fundamental derivation of roughness. Previous studies have indicated that the road profiles are inherently non-Gaussian and non-stationary; this makes the HHT a very suitable method. The central idea of HHT is the empirical mode decomposition (EMD), which is then decomposed into a set of intrinsic mode functions (IMF). The Hilbert transforms can then be applied to the IMF. The HHT appears to be more appropriate than other methods that have been used. Simple examples of two pavement profiles with different degrees of “profile” were analyzed and the HHT was used for both quantitative and qualitative identification of the type of profile.

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

- 1- I would like to know of any applications of HHT in pavement condition analysis.
- 2- Is HHT appropriate for profile analysis?

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

NEW VERSION OF LTPPBIND SOFTWARE FOR PG BINDER SELECTION

Monte Symons
Federal Highway Administration
Midwest Resource Center
19900 Governors Drive, Suite 301
Olympia Fields, Illinois 60461-1021
Telephone: 708-283-3549, Fax: 708-283-3501, Email: Monte.Symons@fhwa.dot.gov

ABSTRACT:

LTPPBind is a Windows-based software program developed by LTPP to help highway agencies select the most suitable and cost-effective Superpave asphalt binder Performance Grade (PG) for a particular site. Based on the original binder selection software SHRPBind, LTPPBind features a database of high and low air temperatures (minimum, mean, maximum, standard deviation, and number of years) for U.S. and Canadian weather stations, along with several modifications that provide users with the ability to select PGs based on actual temperature conditions at their site and at the level of risk designated by their highway agency.

LTPP's revised high temperature PG algorithm is being developed via an LTPP data analysis project. The algorithm is being verified, adjusted and will be implemented into a new version of existing computer program. To adjust the PG for traffic levels higher than standard, Performance Grades are adjusted (Grade Bumping). As a part of this project, new grade bumping values were calculated using the damage-based procedure.

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

- 1- How the user interface may be modified to improve the binder selection?
- 2- Does software include adequate climatic data for binder selection purpose?
- 3- What other features may be added to the software to make it more useful and user-friendly?

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