

## PAVEMENT PERFORMANCE DATA ANALYSIS FORUM

Sponsored by the TRB Data Analysis Working Group, H. J. Ertman Larsen, Chairman

In Conjunction with the Third International Symposium on Maintenance and Rehabilitation of Pavements and Technological Control ("Mairepav03").

July 11, 2003

Amphitheatre B1.15  
School of Engineering, University of Minho  
Guimarães, Portugal

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

0930-1000am **1. PRACTICAL EVALUATION OF ADDITIVES USED FOR SOIL STABILISATION**  
Alex Visser and Fanie Erasmus  
University of Pretoria  
Pretoria, South Africa

1000-1015am Presenter's Questions

1015-1030am	Morning Break
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1030-1100am **2. DYNAMIC BACKCALCULATION METHOD FOR MULTIPLE FWD TIME SERIES DATA**  
Kunihito Matsui  
Tokyo Denki University  
Ishizaka Hatoyama Hiki Saitama, Japan

1100-1115am Presenter's Questions

1115-1145AM **3. PROGRESS IN THE MAINTENANCE AND REHABILITATION OF SURFACED AND UNSURFACED PAVEMENTS WITH ORGANIC SOIL STABILIZERS IN THE USA**  
Sheldon R. Murphy  
Nature Plus Inc.  
Stratford, Connecticut, USA

1145-1200noon Presenters' Questions

1200-0100pm	Mid-Day Break
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0100-0130pm	<b>4. PAVEMENT DATA COLLECTION, PROCESSING, AND INTERPRETATION AT LCPC</b> Philippe Lepert Laboratoire Central des Ponts et Chaussées Nantes, France
0130-0145pm	Presenters' Questions
0145-0215pm	<b>5. ANALYSIS OF CRACK-RELATED INPUT DATA FOR HDM-4</b> András Gulyás Technical and Information Services on National Roads Budapest, Hungary
0215-0230pm	Presenter's Questions
0230-0245pm	Afternoon Break
0245-0315pm	<b>6. EFFECTS OF FWD LOAD-TIME HISTORY ON DYNAMIC RESPONSE ANALYSIS OF ASPHALT PAVEMENTS</b> Waheed Uddin The University of Mississippi University, Mississippi, USA
0315-0330pm	Presenter's Questions
0330-0400pm	<b>X. LTPP/ASCE 4<sup>TH</sup> INTERNATIONAL CONTEST ON LTPP DATA ANALYSIS</b> A. Robert Raab NRC/Transportation Research Board Washington, District of Columbia, USA
0400-0415pm	Presenter's Questions
0415pm	Close of Meeting

## 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, TNA-443  
Transportation Research Board  
500 5<sup>th</sup> Street, NW  
Washington, DC 20001  
United States of America  
Telephone: 202-334-2569, Fax: 202-334-3471, Email: rraab@nas.edu

**TRB's DATA ANALYSIS WORKING GROUP ("the DAWG")  
PRESENTATION ABSTRACT FORM**

TITLE OF PRESENTATION:

ABSTRACT:

*(Guidelines:*

- *Any person who wishes to brief the DAWG on the status of his/her unfinished and unpublished work is invited to submit an abstract.*
- *Each abstract must contain a small set of questions on issues being considered by the submitter in the further development of his/her project.*
- *Each briefing will be followed by a period devoted to consideration of the presenter's questions and requests for advice.*
- *Briefings should focus on techniques for extracting, processing, and analyzing pavement performance data, as well as preliminary results of applications of these techniques.*

*Note: Please delete the guidelines and use this space for your abstract.)*

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

1-

2-

3-

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

NAME: \_\_\_\_\_

MAILING ADDRESS: \_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

TELEPHONE/FAX/EMAIL: \_\_\_\_\_

Completed forms should be sent to:

A. Robert Raab, PhD, PE, FASCE

Senior Program Officer, TRB

Email: rraab@nas.edu

## **PRACTICAL EVALUATION OF ADDITIVES USED FOR SOIL STABILISATION**

Alex Visser and Fanie Erasmus  
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### **ABSTRACT:**

There are numerous products being marketed as a soil stabilizer for unpaved roads. Authorities find it difficult to judge these products as many are influenced by soil conditions and climate. Companies marketing these products are in an equally invidious position, as every authority would like to build test sections and they expect the supplier to provide the product for free. The result is that potentially useful products are not implemented. There have been attempts to use standard laboratory tests such as the CBR or unconfined compressive strength to distinguish between potentially suitable or unsuitable products. Experience has shown that these tests are not necessarily representative of field performance. Other tests such as abrasion and erosion resistance and increased shear resistance have also been recommended.

Because of the difficulty of simulating field conditions in the laboratory, a project is being executed to develop a test protocol that will allow field testing at an affordable cost. The aim of the presentation is to present this test procedure and to stimulate discussion on the merits of the procedure. It consists of constructing small panels of 1m by 3m, the full depth of the layer of 150 mm. Compaction occurs in three layers with a small vibrating roller, to achieve typical field compaction. Normal trafficking occurs over the test panels. A 30 day curing period is allowed, whereafter an evaluation is carried out about the potential moisture sensitivity. This consists of saturating the panel under a 50 mm head of water within a half oil drum for a period of 1 hour. Before and after saturation Dynamic Cone Penetrometer (DCP) measurements are taken.

It was found that good discrimination between additives in an experiment that consisted of a control panel (no stabilizer) and 9 stabilisers. Some materials showed no improvement over the unstabilised materials when wetted, whereas others showed a significant improvement. It was also possible to evaluate the strength gain over time and depth with the DCP. This procedure shows exciting potential for resolving a universal problem.

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

- 1- Has anyone tried a similar procedure?
- 2- Comments about the merits of the procedure.

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

## **DYNAMIC BACKCALCULATION METHOD FOR MULTIPLE FWD TIME SERIES DATA**

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### **ABSTRACT:**

#### Development of Efficient Dynamic Backcalculation method

It is more desirable to conduct backcalculation which consider the dynamic effect of FWD test, because the test is impulsive. We have developed the dynamic backcalculation software called DBALM and still keep improving it. What we mostly considered in our mind are computational efficiency and computational accuracy.

#### What is the most efficient algorithm for this purpose?

Forward analysis based on FEM is very time consuming because of large degrees of freedom. Utilization of Ritz vector reduction method leads to a drastic reduction of computational time. Sensitivity analysis required in our backcalculation is also conducted using the same Ritz vectors.

Formation of global matrices, which are composed of many element mass, damping and stiffness matrices, is computationally costly. After the second iteration, layer damping and stiffness matrices are constructed skipping the process of element matrices formation.

#### Are there any other good ways to maintain computational accuracy?

Numerical integration is commonly used to solve a system of multiple degrees of freedom. Computational accuracy depends on a size of time step. A small step size increases computational time, while a large step size decreases computational accuracy. In our study, the reduced system of equations of motion is transformed into a first order system of equation, an eigenvalue analysis is conducted and analytical solution is derived assuming an external force in a piecewise linear form. Our dynamic results are compared with the results from major FEM software. They are found to have good agreement.

In the backcalculation process, since layer damping coefficient and layer modulus are completely different in magnitude, scaling of variables used in optimization is introduced to reduce numerical instability. Gauss-Newton method coupled with truncated singular value method is utilized to achieve numerical stability.

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

- 1- Is there any other efficient dynamic backcalculation method?
- 2- Is there any suggestion on backcalculation method superior to Gauss-Newton method?
- 3- Is there any suggestion on the best way to introduce non-linearity of the pavement structure?

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

## **PROGRESS IN THE MAINTENANCE AND REHABILITATION OF SURFACED AND UNSURFACED PAVEMENTS WITH ORGANIC SOIL STABILIZERS IN THE USA**

Sheldon R. Murphy

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### **ABSTRACT:**

Both public and private sectors seek cost-effective treatments to improve long-term performance of conventional primary and secondary roads, to better use their limited road maintenance budgets and to help address environmental regulations mandating dust control, sediment control for unpaved gravel or soil road surfaces.

Suitable road materials are becoming more expensive and scarce. Importation of materials increases project costs. More economical methods of building roads must include using locally available soils of poorer quality. Often soil stabilization technology can upgrade these soils to strengthen existing road base and sub-base materials to provide roads with extended life and heavier traffic duty.

This need for answers was recognized by the World Bank when it funded a soil stabilizer study - BIRF-3685 Paraguay, "A Comparative Study of the Performance of Soil Stabilizers in Secondary, Unsurfaced Roads in Paraguay" and is the most comprehensive ever compiled. Recent requirements by the USAID of usage of soil stabilizers in road maintenance and rehabilitation projects (Honduras and Bangladesh) has accelerated interest. The US Federal Lands and Highways Department has undertaken validating projects into soil stabilizer application for improving unpaved road performance and reducing maintenance needs.

Potential benefits for stabilizing paved roads include capacity increase, reducing surface distress, reducing cost of construction. For unsurfaced roads: improved structure, reduction of road surface defects, maintenance cost and frequency, and aggregate and fines loss. Stabilization can improve the structure of gravel roads for "chip and seal" treatment. Appropriate study designs and measurement parameters/data collection methods are needed to advance and validate this technology.

Questions remain, more data and proper analysis are needed, other studies must be pursued. Work and progress in Pennsylvania, Montana, Arizona and Utah projects will be presented and discussed.

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

- 1- How does one best capture the economic benefits of stabilization?
- 2- What road performance measurement(s) are most suitable for validating results?
- 3- How does one best work through the inertia and politics (both inside and outside government groups) to new road maintenance and rehabilitation concepts and technology?

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

## PAVEMENT DATA COLLECTION, PROCESSING AND INTERPRETATION AT LCPC

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### ABSTRACT:

The LCPC is a public organism that is conducting researches and developments in the various domains of civil engineering. It is especially working on the development and improvement of data acquisition processing and interpretation tools.

Regarding data acquisition, two aspects are mainly addressed at LCPC, the objective of which is to provide the road managing authorities with adequate high-speed data collection devices. First, some efforts are devoted to the development of a so-called “reference procedure and system” for automatic recording and processing of pavement surface distresses. This procedure / system itself does not aim at being operational for network level. It has a low measurement rate, only applies in specific condition of application, etc. Nevertheless, it should be useable to provide the reference surveys that are required to qualify operational devices, which implies high repeatability, reproducibility, and relevance. Secondly, LCPC is involved in both the evaluation of various new rolling wheels Deflectometers, and the development of alternative mechanical condition assessment principles such as dynamic monitoring of pavement.

Regarding data processing, the LCPC has just completed the development of software that applies most of the classical data processing operations:

- Realignment of various measurements provided by the monitoring devices on the database reference system,
- Combination or comparison of road measurements with a sophisticated and effective encoding language,
- Aggregation of data along sections of different length, statistical analysis,
- Presentation of results on route diagrams, on statistical diagrams (histograms, pies, etc.)
- Introduction of final data and information in the road databank,
- Etc.

Finally, along the six last years, large parts of LCPC activities in that field were directed towards the preparation of a new pavement management system, including pavement performance and technico economic models. Road managing authorities should use this system to:

- Assess the condition of their networks;
- Select the best appropriate maintenance options (strategies, policies), and justify their choice especially on economic basis;
- Prepare pluri-annual maintenance program.



These models are developed within international cooperation and projects: pavement performance models are studied with the Ministry of Transport of Quebec (MTQ) whereas economic models are mainly developed within European project.

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

- 1- Regarding data collection: According to Quality Assurance Plan, any device used to collect data for an operational survey should be qualified; Besides repeatability and reproducibility, the “exactness” of the device must be assess; How is obtained the survey that is used as reference to evaluate the “exactness” of surface distresses monitoring devices ?
- 2- Regarding pavement performance model: Data processing is often facing the problem that the impact of some explanatory variables is hidden by the effect of design. For instance, the heavy traffic and the structural strength of the pavement are explanatory variables for cracking evolution. Nevertheless, if the sections of the sample used in the statistical analysis were designed according to rules that take into account these effects, this analysis can fail to enlighten these explanatory variables. How to overcome this difficulty, which can lead to wrong interpretation of the data ?
- 3- Regarding technico-economic models: Do you know existing models to evaluate:
  - The economic value of a pavement, taking into account its condition (distresses);
  - The social and economic value of the noise generated by traffic, especially in urban area;
  - The economic benefit from using recycled materials and techniques ?

**PRESENTER'S STATEMENT:** These works are still in progress, and have not been submitted, as a whole, for presentation or publication at another meeting.

## **ANALYSIS OF CRACK-RELATED INPUT DATA FOR HDM-4**

András Gulyás

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### **ABSTRACT:**

A new generation of National Road Databank has been developed recently in Hungary. Inventory, traffic and condition data are collected by district road administrations. The new Road Databank is based on an official digital map combining traditional and node point identification methods.

In Hungary HDM-III has been used for project level analysis while a network level PMS based on the Finnish HIPS has been used mainly for resource allocation purposes. Implementation of HDM-4 is in its way therefore input data availability has become an important question requiring supervision of the present data analysis practice.

As a step of the implementation process an interface has to be developed between the road databank and the HDM-4 in order to provide automatic input generation. Surface distress data represent a specific data group. Every spring a visual inspection is performed on the national road network using a microprocessor based data collecting device. 16 different distress types are collected together with their correct location and a general surface condition index is calculated as well.

The National Road Databank stores 4 main distress types also used as input by HDM-4, these are: potholes, raveling, total cracks and edge breaks. HDM-4 divides cracks into structural and transverse thermal cracking, moreover it distinguishes wide cracking as well. Although detailed cracking data are available at district level, it would not be useful to process all these data to fulfill special HDM-4 input requirements. A mathematical-statistical analysis has been performed on detailed cracking data in order to get simple factors substituting specific crack-related input data for HDM-4 application.

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

- 1- How the data conversion between different cracking protocols and the HDM-4 input requirement can be ensured?
- 2- Is there any practical experience of an interface between a road databank and HDM-4?

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

## **EFFECTS OF FWD LOAD-TIME HISTORY ON DYNAMIC RESPONSE ANALYSIS OF ASPHALT PAVEMENTS**

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### **ABSTRACT:**

The traditional static linear elastic analysis used to interpret FWD dynamic deflection data and backcalculate in situ modulus values ignore the shape, duration, and frequency of FWD load pulses. The objective of this presentation is to share the results of a recent study that investigated these dynamic effects on pavement structural response analysis. The FWD load and deflection history data, measured on an asphalt pavement section of US45N Section 1 at Station 461+05, are analyzed in this study. These data were collected for a subgrade characterization project sponsored by the Mississippi DOT. The in situ modulus values are validated by the three dimensional-finite element (3D-FE) dynamic analysis without damping. The implicit 3D-FE analysis shows a natural frequency of about 8 Hz for this pavement. The explicit 3D-FE dynamic analyses conducted using a harmonic load at 6, 8, and 12 Hz frequencies show a resonance effect at 8 Hz. This resonance effect is larger for peak sensor deflections away from the load. Different sine load pulse durations ranging from 20 to 200 msec were used for deflection response analysis and the results are compared with the measured deflection response for the FWD load pulse of 70 msec. FWD load pulse durations of 40-100 msec simulate field conditions better because reasonable comparisons of the calculated peak deflections and the measured deflections are shown with maximum 7% absolute difference. The use of different load pulse durations generated by three different FWD models show significant differences in the peak deflection values compared to the measured peak deflections using a typical two-peak FWD load pulse of 70 msec duration. On the other hand, the load pulse shape affects the deflection-time history shapes. There is no significant effect on the calculated vertical compressive stress distribution.

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

- 1- The use of full FWD load and deflection history data may explain differences in the backcalculated modulus values from different FWD models. Any work done in this area?
- 2- The FWD load pulse duration outside the 40-100 msec range may not be desirable considering effects on deflections calculated from the 3D-FE dynamic response analysis. Any comment from the FWD manufacturers or other researchers?
- 3- Any study done on the SHRP-LTPP sections using FWD time history data to backcalculate effective in situ modulus values?

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

## **LTPP/ASCE 4<sup>TH</sup> INTERNATIONAL CONTEST ON LTPP DATA ANALYSIS**

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### **ABSTRACT:**

The Long-Term Pavement Performance studies, which are being pursued by the US Department of Transportation's Federal Highway Administration, co-sponsors with the American Society of Civil Engineers an international contest that focuses on the use of the LTPP database for pavement performance data analysis. This year, LTPP and ASCE are sponsoring the fourth contest in this series.

This presentation will include

- Some LTPP history
- LTPP's objectives and experiments
- LTPP database components
- DataPave 3.0 software
- DataPave Online
- Contest objectives
- Entry evaluation criteria
- Entry and award categories
- Sources of further information

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

- 3- What are the barriers or impediments to international participation in the contest?
- 4- What changes or additions would make the contest more appealing and result in more entries?
- 5- How would you improve the briefing (a copy is attached)?

**PRESENTERS' STATEMENT:** Not applicable.

# ATTACHMENT

## Presentation Slides / DAWG Forum, Guimaraes, Portugal, 11 July 2003

Slide 1

LTPP/ASCE  
4<sup>th</sup> International Contest  
on LTPP Data Analysis

Slide 5

LTPP SPS Experiments

SPS-1	Strategic Study of Structural Factors for Flexible Pavements
SPS-2	Strategic Study of Structural Factors for Rigid Pavements
SPS-3	Preventative Maintenance Effective for Flexible Pavements
SPS-4	Preventative Maintenance Effective for Rigid Pavements
SPS-5	Rehabilitation of AC Pavements
SPS-6	Rehabilitation of Jointed PCC Pavements
SPS-7	Bonded PCC Overlays on Concrete Pavements
SPS-8	Study of Environmental Effects in the Absence of Heavy Loads
SPS-9	Validation of SHRP Asphalt Specification and Mix Design (Superpave)

Slide 9

LTPP/ASCE Analysis Contest

**Objectives**

- To foster the use of DataPave by present and future pavement engineers
- To foster the use of the LTPP database by present and future researchers

Slide 2

LTPP: Long-Term Pavement Performance

- 20 years of collection of pavement performance data
- 1900+/- in-service test sections throughout the US and Canada
- A cooperative research program involving USDOT, States, and Provinces

Slide 6

LTPP Database

<b>MODULES</b>	<b>TABLES</b>	<b>ELEMENTS</b>
<ul style="list-style-type: none"><li>• Climatic</li><li>• General</li><li>• Inventory</li><li>• Maintenance</li><li>• Monitoring</li><li>• Rehabilitation</li><li>• SMP</li><li>• SPS (10)</li><li>• Traffic</li></ul>	<ul style="list-style-type: none"><li>• Deflection</li><li>• Profile</li><li>• Friction</li><li>• Distress</li><li>• etc</li></ul>	<ul style="list-style-type: none"><li>• Date</li><li>• Time</li><li>• Temperature</li><li>• Individual data elements</li></ul>

Slide 10

Evaluation Criteria

- Originality of the concept
- Demonstrated use of the LTPP database
- Usefulness of the analytical results
- Organization of the paper and presentation (including clarity and style)

Slide 3

LTPP Objectives

- Evaluate existing design methods.
- Develop improved design methodologies for rehabilitation
- Develop improved design equations for new pavements.
- Determine the effects on performance of specific design, loading, or maintenance parameters
- Establish a national database for analysis, design, and research

Slide 7

"DavePave 3.0"  
User-Friendly Access to LTPP Data

- Actual data from LTPP experiments
- Site selection by experiment or from map
- Data viewable by
  - Map module (displays information for all LTPP sites in GPS map form)
  - Section Presentation module (provides specific information about location, experiment type, pavement layer, and selected falling-weight deflectometer (FWD) profiles)
  - Chart-Trend module (presents time histories of several key distress indicators)
  - Database Exploration and Extraction module (enables extraction of appropriate tables and fields of the selected sections.

Slide 11

Entry and Award Categories

1. **Undergraduate Students**  
(individual or team entry)
2. **Graduate Students**  
(individual or team entry)
3. **Partnership**  
(individual or team entry by state, university, and/or consultant personnel)
4. **Curriculum**  
(individual entry of classroom use of DataPave and LTPP database by university faculty)

Slide 4

LTPP GPS Experiments

GPS-1	Asphalt Concrete (AC) on Granular Base
GPS-2	AC on Bound Base
GPS-3	Jointed Plain Concrete Pavement
GPS-4	Jointed Reinforced Concrete Pavement
GPS-5	Continuously Reinforced Concrete Pavement
GPS-6A	Existing AC Overlay on AC Pavements
GPS-6B	New AC Overlay on AC Pavements
GPS-7A	Existing AC Overlay on Portland Cement Concrete (PCC) Pavements
GPS-7B	New AC Overlay on PCC Pavements
GPS-9	Unbonded PCC Overlays on PCC Pavements

Slide 8

DataPave Online

Slide 12

Information Sources

<http://www.fhrc.gov/pavement/ltpcontest2003.htm>  
<http://www.datapave.com>

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