2006 INTERNATIONAL CONFERENCE ON PERPETUAL PAVEMENT

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Perpetual Asphalt Pavements: Materials, Analysis/Design, Construction, and Other Considerations

Carl L. Monismith
Pavement Research Center
University of California, Berkeley

2006 International Conference on
Perpetual Pavement
Columbus, Ohio
September 13-15, 2006

Presentation Overview

- Background
  - contributions to current approach to long-life (perpetual pavement) design
- Example
  - design and construction (I-710 full depth section)
- Conference sessions
  - Categories of papers
- Additional considerations/challenges

MAKING THE BEST USE OF LONG-LIFE PAVEMENTS IN EUROPE: THE WORK OF ELLPAG

Brian Ferne and Mike Nunn

ORITE International Conference on Perpetual Pavements, Columbus, Ohio - September 2006

ELLPAG

is a FEHRL Working Group

(Forum of European National Highway Research Laboratories)

with support from CEDR

(Conference of European Directors of Roads)

Conférence Européenne des Directeurs des Routes
Conference of European Directors of Roads

Four main aims of ELLPAG

- to determine best designs
- to determine economic benefits
- to understand deterioration mechanisms
- to encourage their use

With a particular emphasis on the needs of the structural support layers

Perpetual Pavements: The Ontario Experiment

- Becca Lane (MTO)
- Sandy Brown (OHMPA)
- Susan Tighe (CPATT)

Design Concept

- Thin asphalt pavements readily crack and rut under repeated loading of heavy traffic
- In thick asphalt pavements, the potential for fatigue cracking is reduced and pavement distresses (cracking and rutting) occur only in the surface layer.
- When surface distresses reach an unacceptable level, the surface course is removed and replaced.
- Periodically renewing the driving surface keeps the pavement serviceability high throughout the life of the pavement.

Table 1: Scheduled Perpetual Pavement in Ontario

Route	Hwy 402	Hwy 406	Hwy 7	Red Hill Creek Expressway
Location	Sarnia	Thorold	Carlton Place	Hamilton
Authority	MTO	MTO	MTO	City of Hamilton
AADT	20,400	25,470	21,900	70,000
Percent Trucks	25%	7%	10%	
Design ESALs (millions)	38 (18 years) 146 (50 years)	42 (50 years)	28 (30 yrs)	40 (20 years) 90 (50 years)
Designer	MTO	MTO / Golder Associates	MTO / Jacques Whitford	Golder Associates
Design Methodology	AASHTO '93 DARWin / PerRoad 2.4	AASHTO '93 DARWin	AASHTO '93 DARWin	AASHTO '93 DARWin / PerRoad 2.4
Performance Period	50 years	50 years	50 years	50 years
Total HMA Thickness (mm)	340	250	230	240
Rich Bottom Mix in Total HMA	Trial 1 – 80 mm Trial 2 – None	Yes 80 mm	Yes 80 mm	Yes 80 mm
Total Granular Base (mm)	550	400	500	540

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SEASONAL AND LOAD RESPONSE INSTRUMENTATION OF THE WAY-30 PERPETUAL PAVEMENTS

Shad M. Sargand, Russ Professor

Issam S. Khoury, Research Engineer
Department of Civil Engineering Ohio University

Michael T. Romanello, Staff Engineer,
BBC & M Engineering, Inc., Columbus, OH

J. Ludwig Figueroa, Professor
Department of Civil Engineering Ohio University

September 13, 2006

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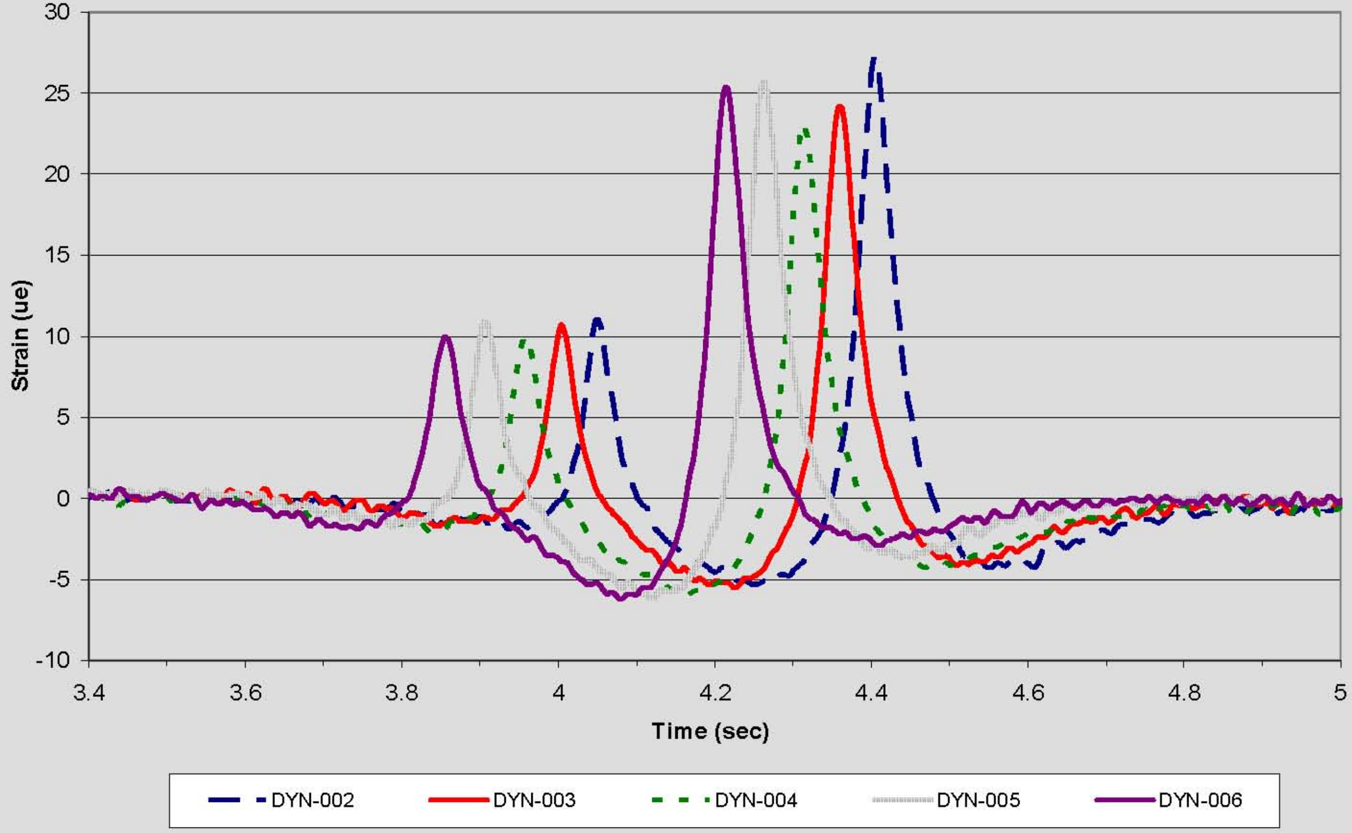
Outline

- Test Section Location and Characteristics.
- Instrumentation.
- Load Response Testing.
- Preliminary Results.
- Summary and Conclusions.

Longitudinal Strain – Sect. 664 (AC2-390182) FRL Layer

30 mph Test: ODOT 28.2 Kip Single Axle Truck



Reconstructing the Silk Road in Afghanistan

DISCUSSION: The application of perpetual asphalt pavement technology for the reconstruction of the Kandahar to Herat road in Afghanistan

Presented by:

Kent Lande, PE

Alberto Garcia, PE

Eric Cook, PE

September 13, 2006

Pavement conditions

Security

- **Security subcontractor**
  - Expatriate resources for key staff
  - GOA MOI Security personnel
  - External coordination with:
    - Government of Afghanistan MOI
    - US Military and ISAF
    - Provincial officials and village elders
- **De-mining**
  - Preconstruction requirement
- **Additional planning factors**
  - Physical security of campsites
  - Vehicle movement
  - Worksites
- **Quality of life for project staff**
- **Cost/benefit**
  - Approx 8% of total program value

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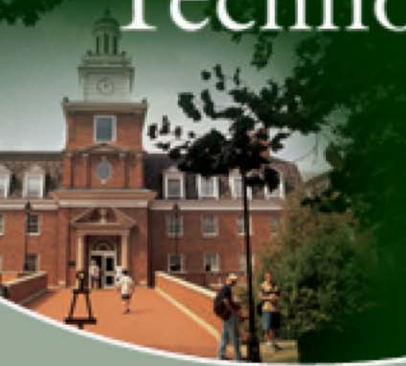

Base Type Selection

Shad Sargand

International Conference on Perpetual Pavement

Columbus OH

September 2006

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OUTLINE

- Pavement performance
- Purpose of base
- Base type effect on subgrade moisture
- Base type effect on deflection
- Base type effect on surface distress
- Findings
- Design Considerations
- Recommendations

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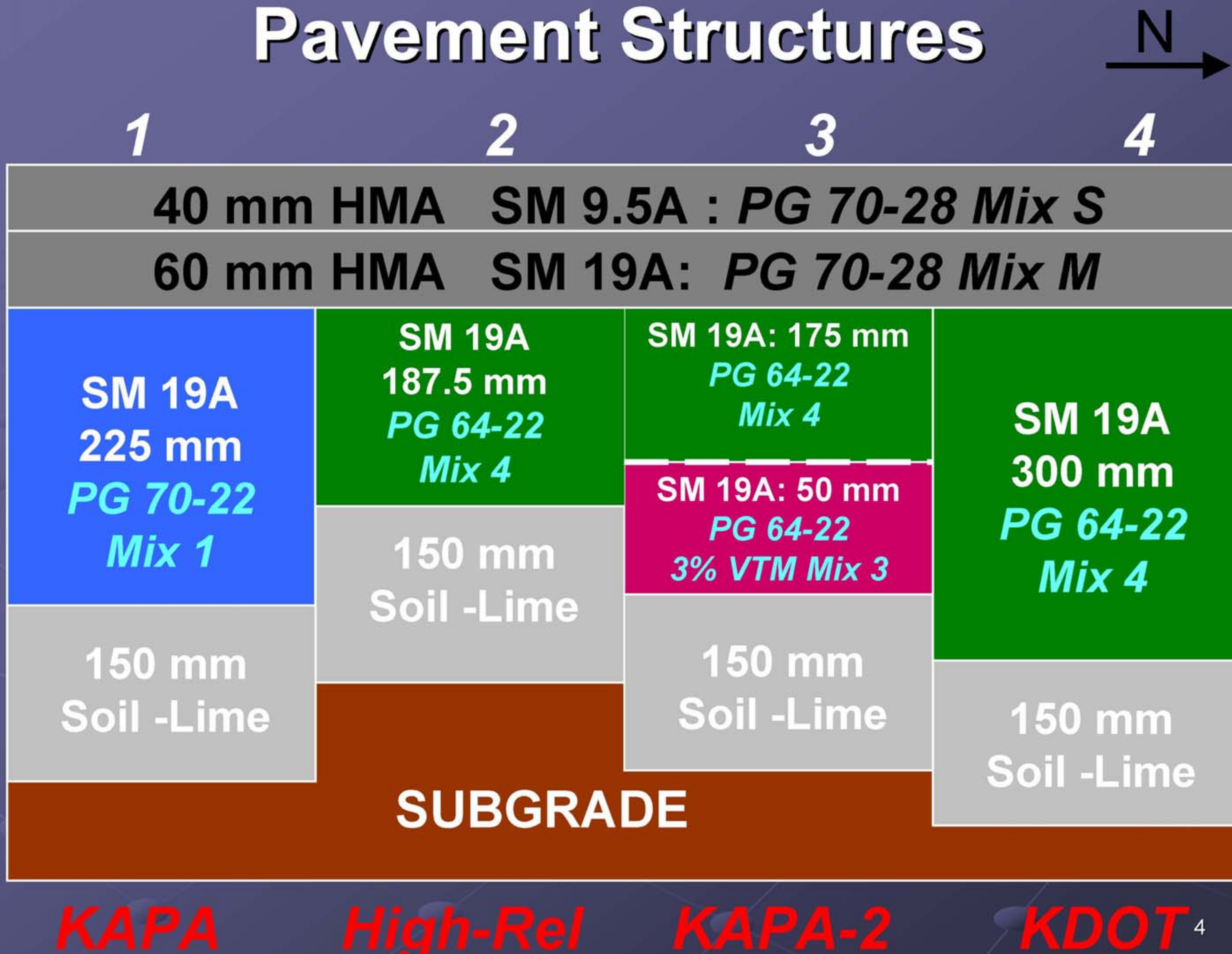
The dynamic response of Kansas perpetual pavements under vehicle loading

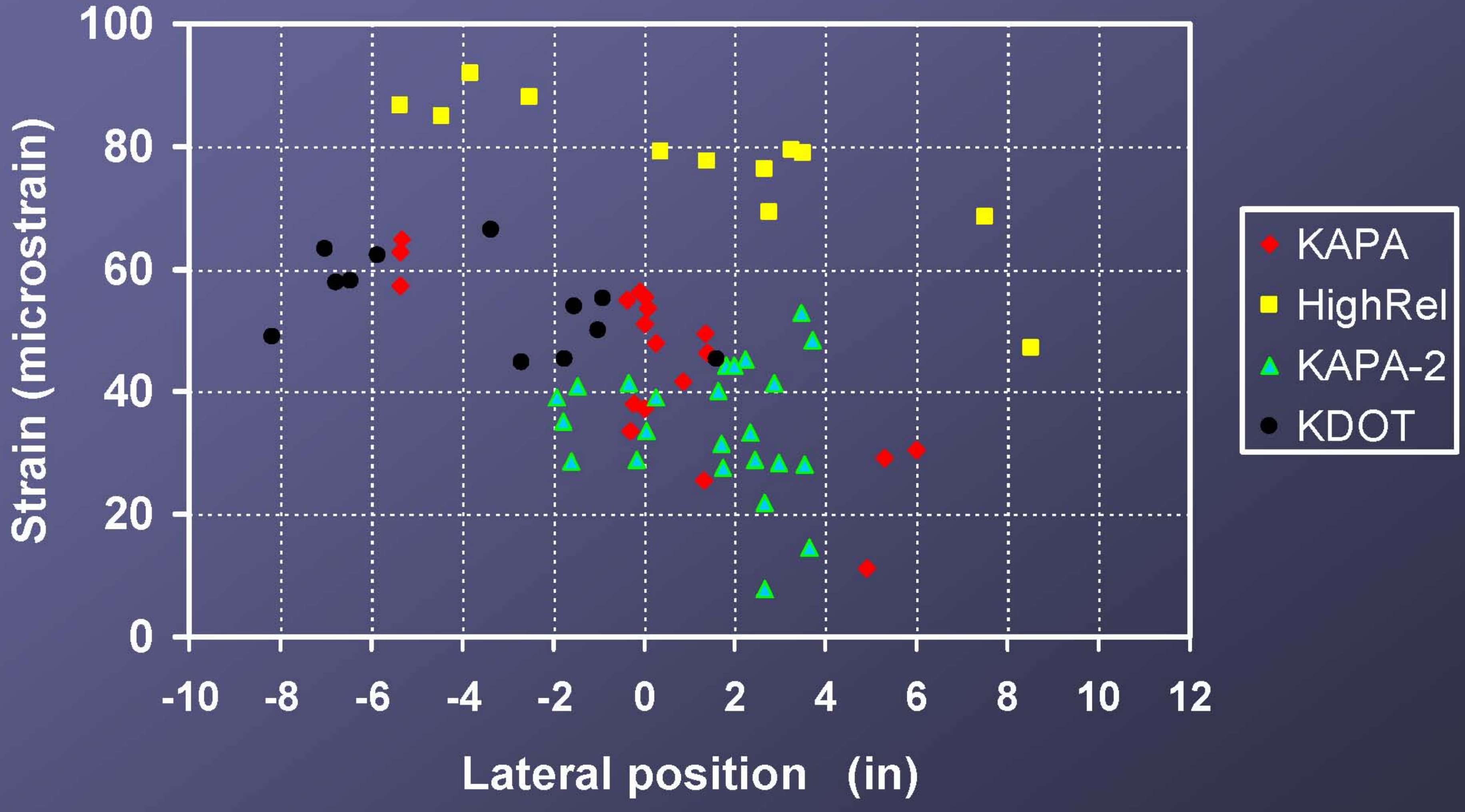
Stefan Romanoschi, KSU
Andrew Gisi, KDOT
Cristian Dumitru, KSU

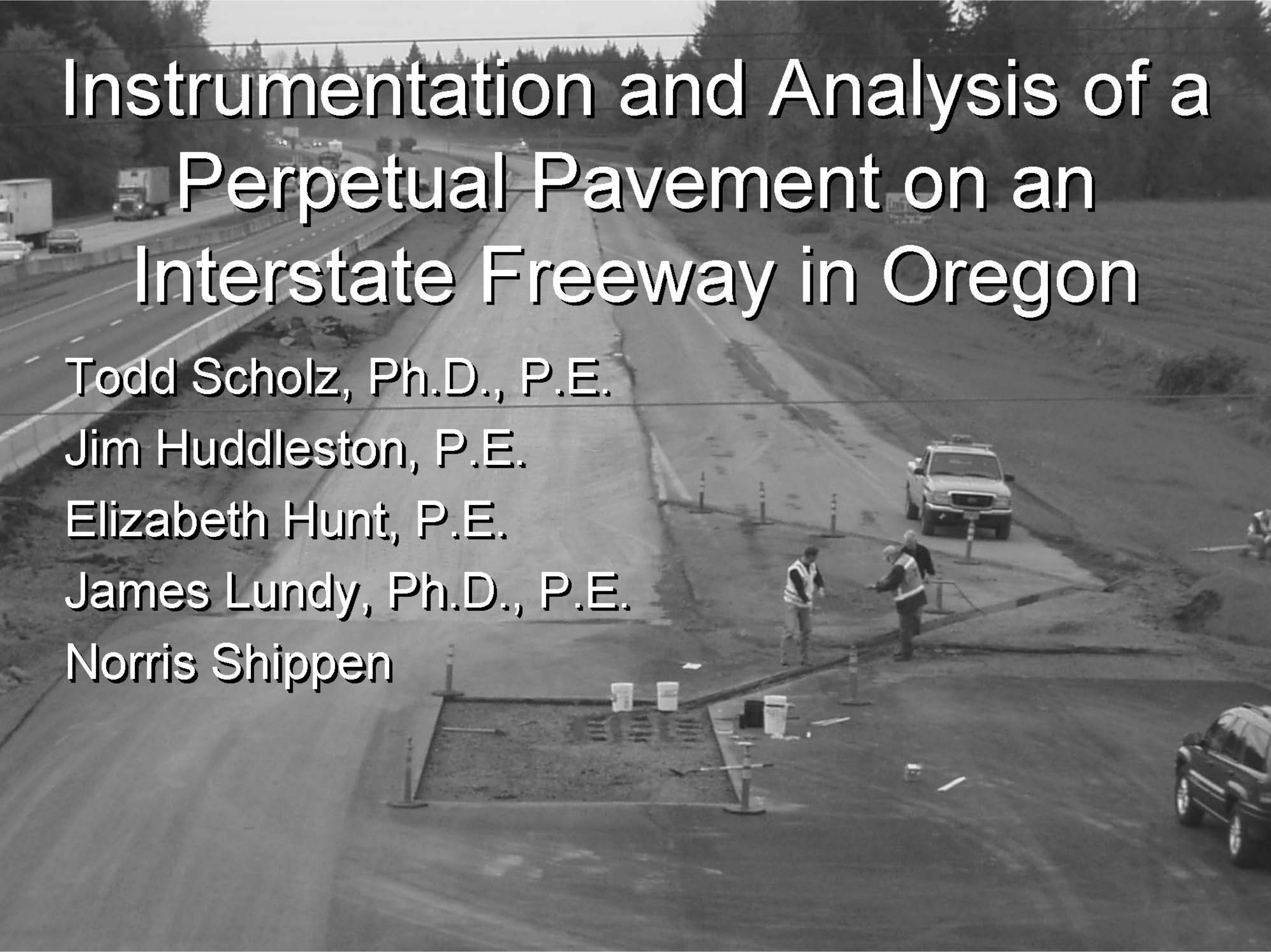
K-State

Pavement Structures



Transverse Strain – 45mph





Instrumentation and Analysis of a Perpetual Pavement on an Interstate Freeway in Oregon

Todd Scholz, Ph.D., P.E.

Jim Huddleston, P.E.

Elizabeth Hunt, P.E.

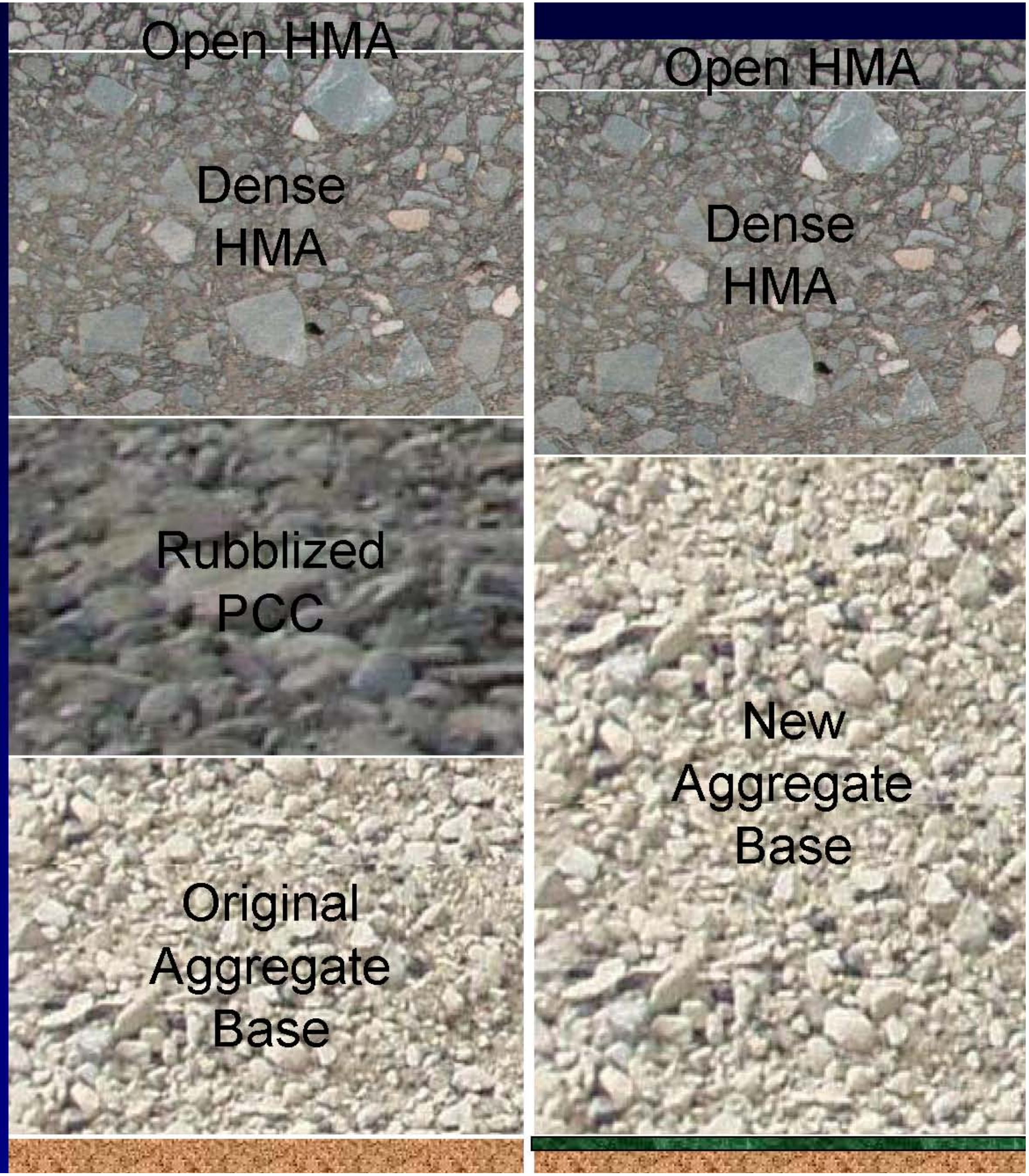
James Lundy, Ph.D., P.E.

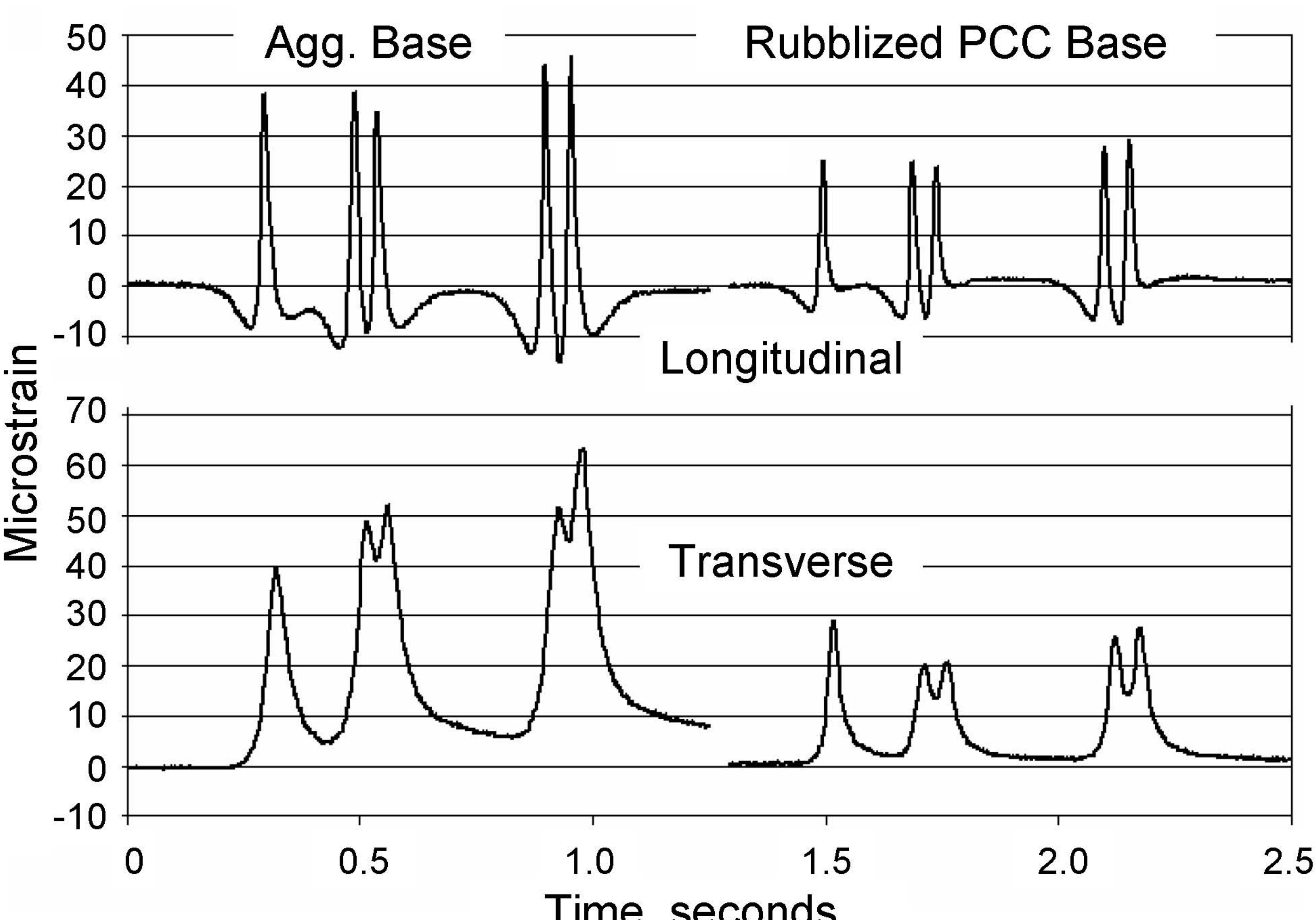
Norris Shippen

Presentation Outline

- Introduction
- Project Location
- Structural Design
- Mechanistic-Empirical Analysis
- Pavement Instrumentation
- Preliminary Data
- Conclusions

Structural Design - Comparison





Agg. Base
Rubblized PCC Base
Longitudinal
Transverse
Microstrain
50
40
30
20
10
0
-10
70
60
50
40
30
20
10
0
-10
0
0.5
1.0
1.5
2.0
2.5
Time, seconds

Pennsylvania's Bradford Bypass
A Perpetual Pavement

Carlos E. Rosenberger, P.E., Asphalt Institute
Thomas J. Zurat, Jr., P.E., Pennsylvania Department of Transportation
Ronald J. Cominsky, P.E., Pennsylvania Asphalt Pavement Association

Introduction

Thickness Design

Material Selection

Economics

Advertising and Awarding the Contract

Construction Follow-Up

中美合作项目-永久路面

Sino-U.S. Cooperation Project---Perpetual Pavement

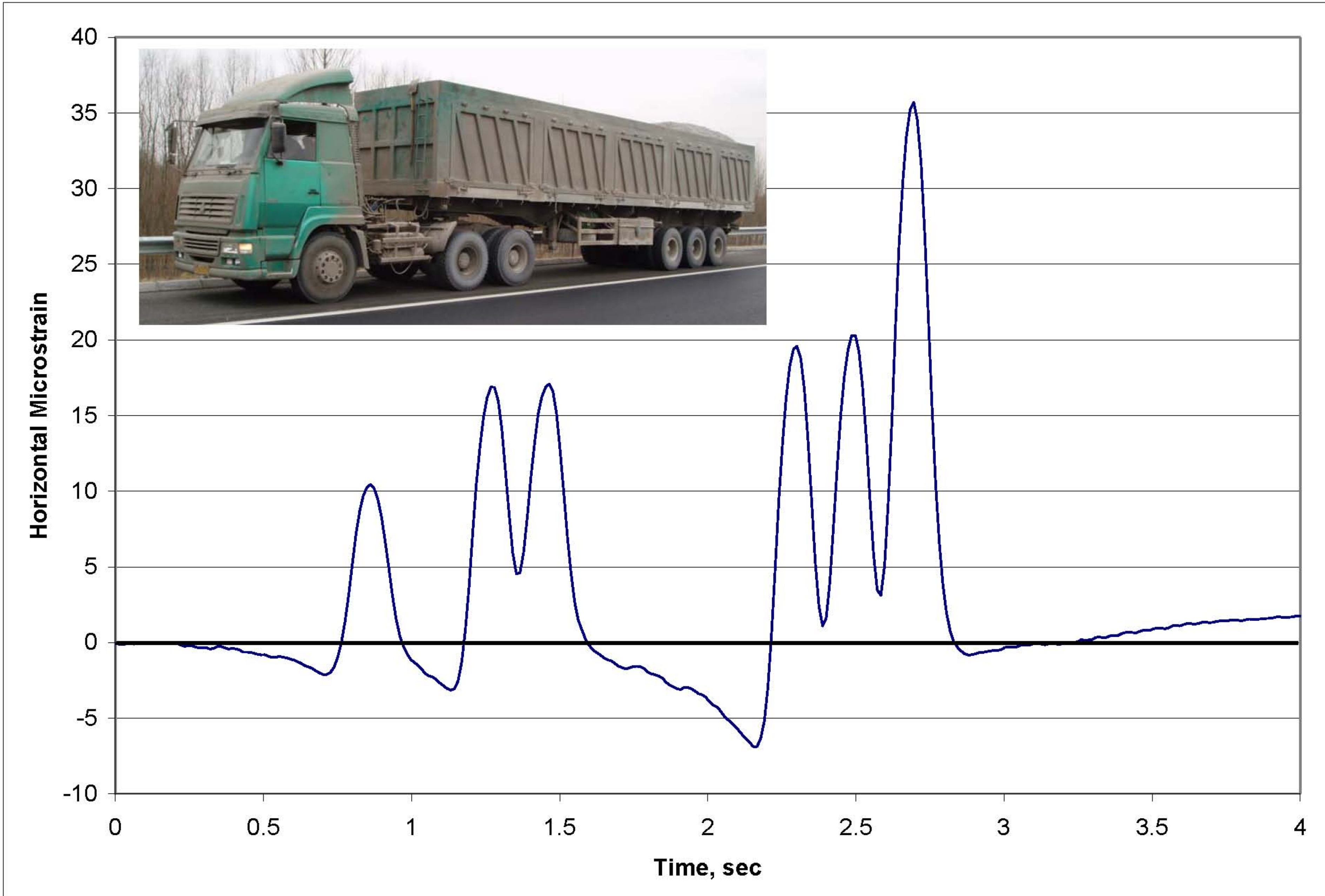
山东省交通厅公路局 **Shandong DOT Highway Bureau**

副局长 研究员 杨永顺 **Yongshun Yang, Vice Director**

2006年9月•Columbus, Ohio • September 2006

超载车辆问题 Overweight Vehicles

Dynamic Pavement Response



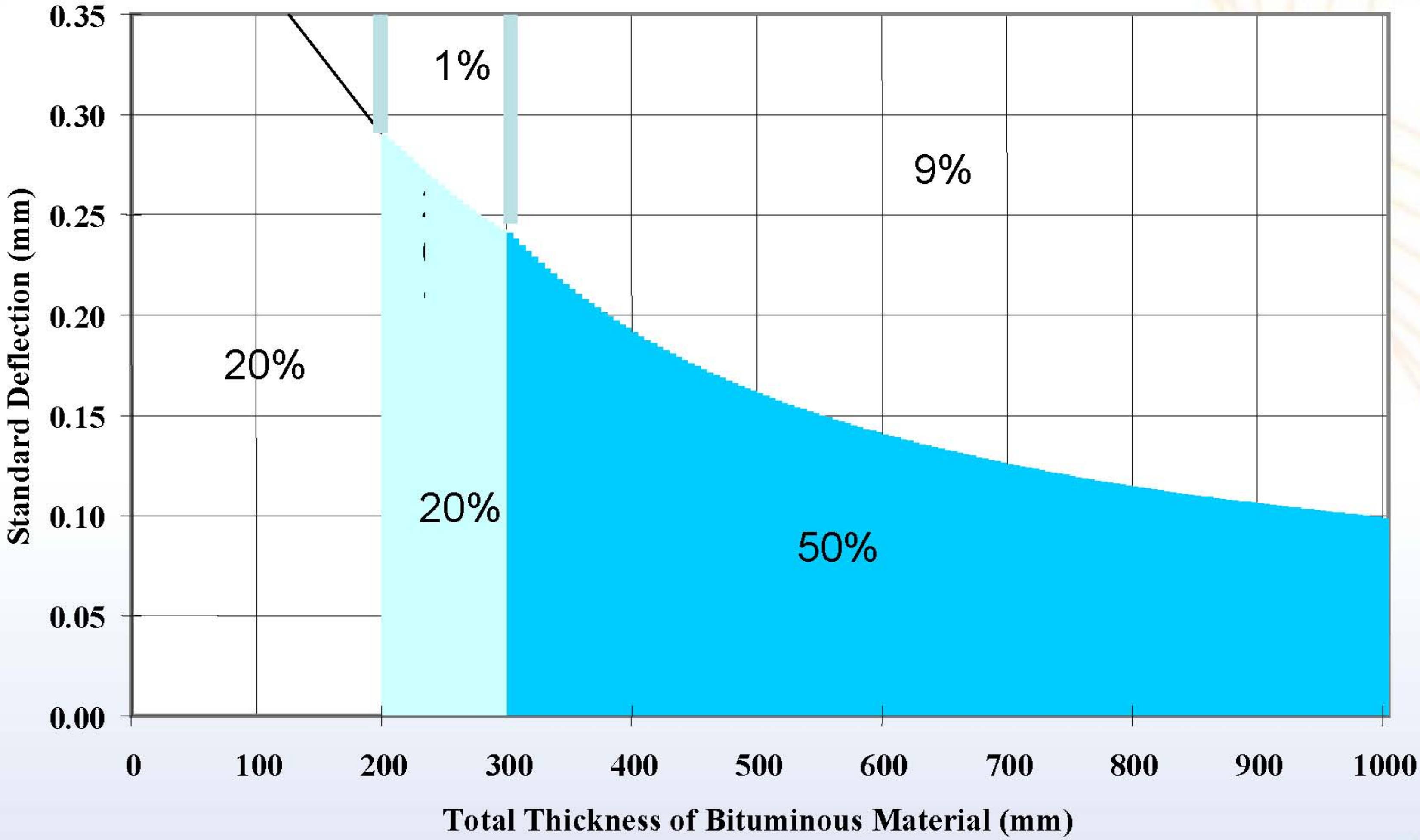
Assessment and Maintenance of Long-Life Flexible Pavements

Presented by Mike Nunn

International Conference on Perpetual Pavements

Columbus, Ohio 13-15 September 2006

Potential impact of RP's on HA network?



International Conference on Perpetual Pavement

"Laboratory Investigation of Anisotropic Behaviour of HMA"

AUTHORS: Prof. Robert Liang

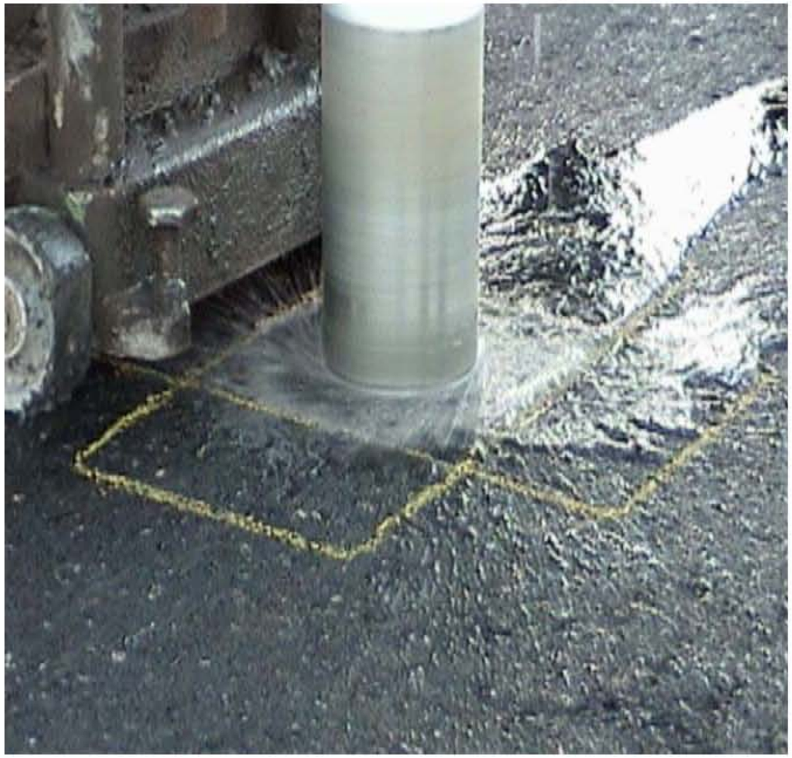
Dr. Bilal Abu Alfoul
Mohammad Khasawneh

PRESENTER: Mohammad Khasawneh

Sep. 14, 2006

Providing solutions to highway building materials problems

Asphalt Aging - Actual versus Predicted



Mike Farrar, Mike Harnsberger, Ken Thomas, William Wiser, Janet Wolf

Western Research Institute

September 14, 2006

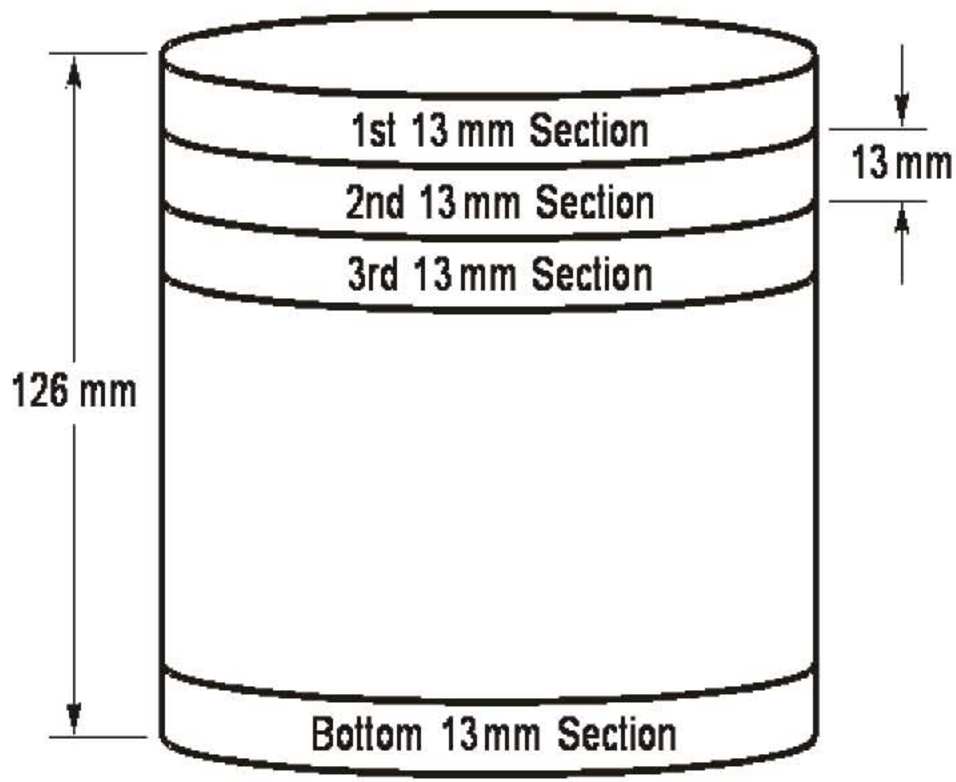
International Conference on Perpetual Pavement
Columbus, Ohio

Asphalt field aging compared to predicted aging based on:

- Global Aging System
  - Published 1995 (AAPT, Vol. 64)
  - Integral part of NCHRP 1-37A Mechanistic-Empirical Design Guide
- PAV Model
  - NCHRP 9-23
  - Suggested as an addendum to AASHTO R-28

"Accelerated Aging of Asphalt Binder Using a Pressurized Aging Vessel (PAV)"

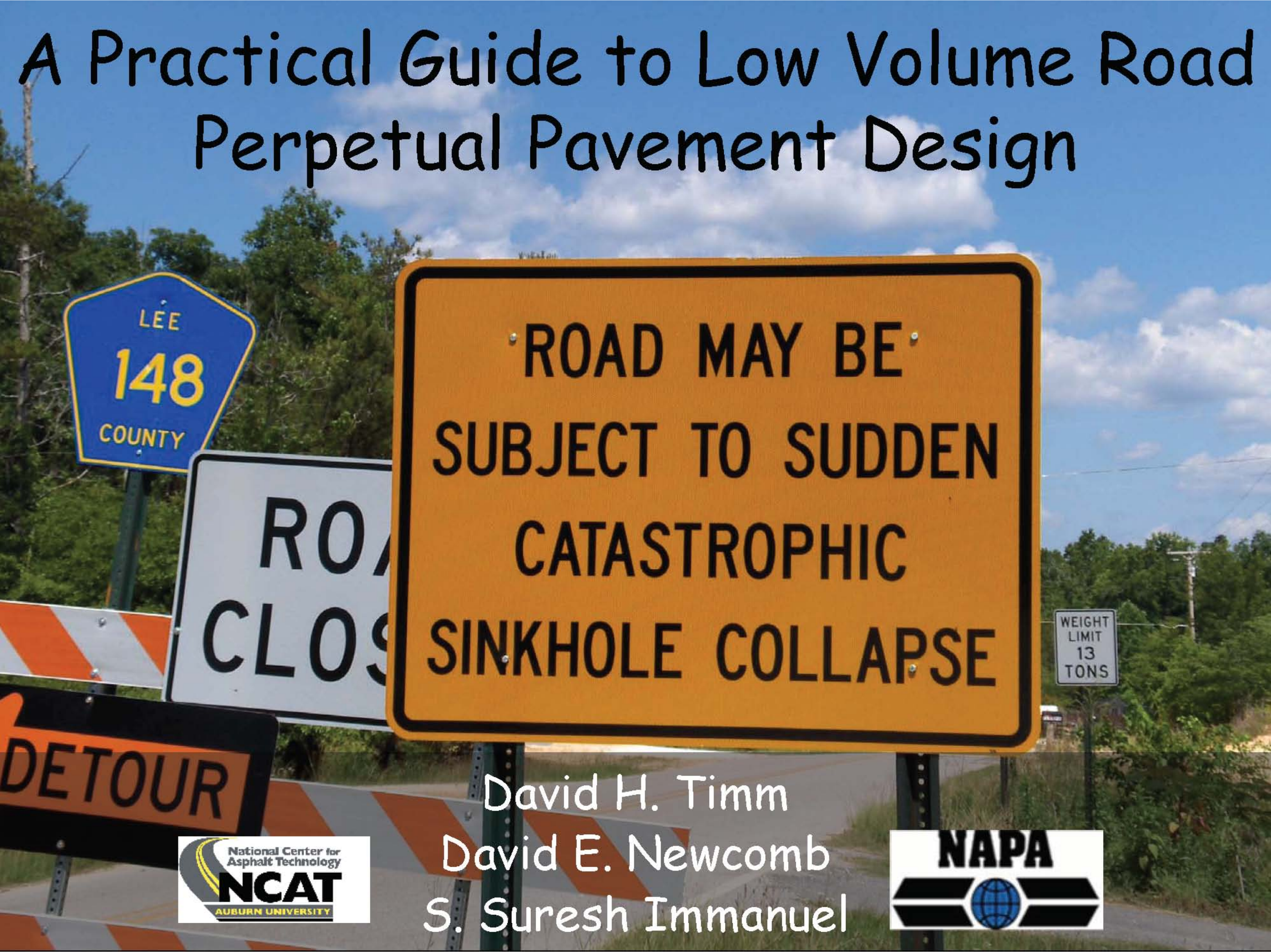
Shoulder coring (Nov. 2005)



Conclusions

- Reduction of extracted viscosity from the top 13-mm to the next 13-mm ranged from 48% to 70% (average 65%)
- Minor differences between the 13-mm sections below the top 13-mm section
- Extracted four-year viscosity is substantially greater than the GAS predicted viscosity, particularly in the top 13-mm of pavement
- In this limited analysis of the PAV aging model confined to just AZ1-1, the depth of the RTFO/PAV viscosity corresponding to 48 months was estimated at 40 mm

A Practical Guide to Low Volume Road Perpetual Pavement Design



David H. Timm
David E. Newcomb
S. Suresh Immanuel

National Center for Asphalt Technology
NCAT
AUBURN UNIVERSITY

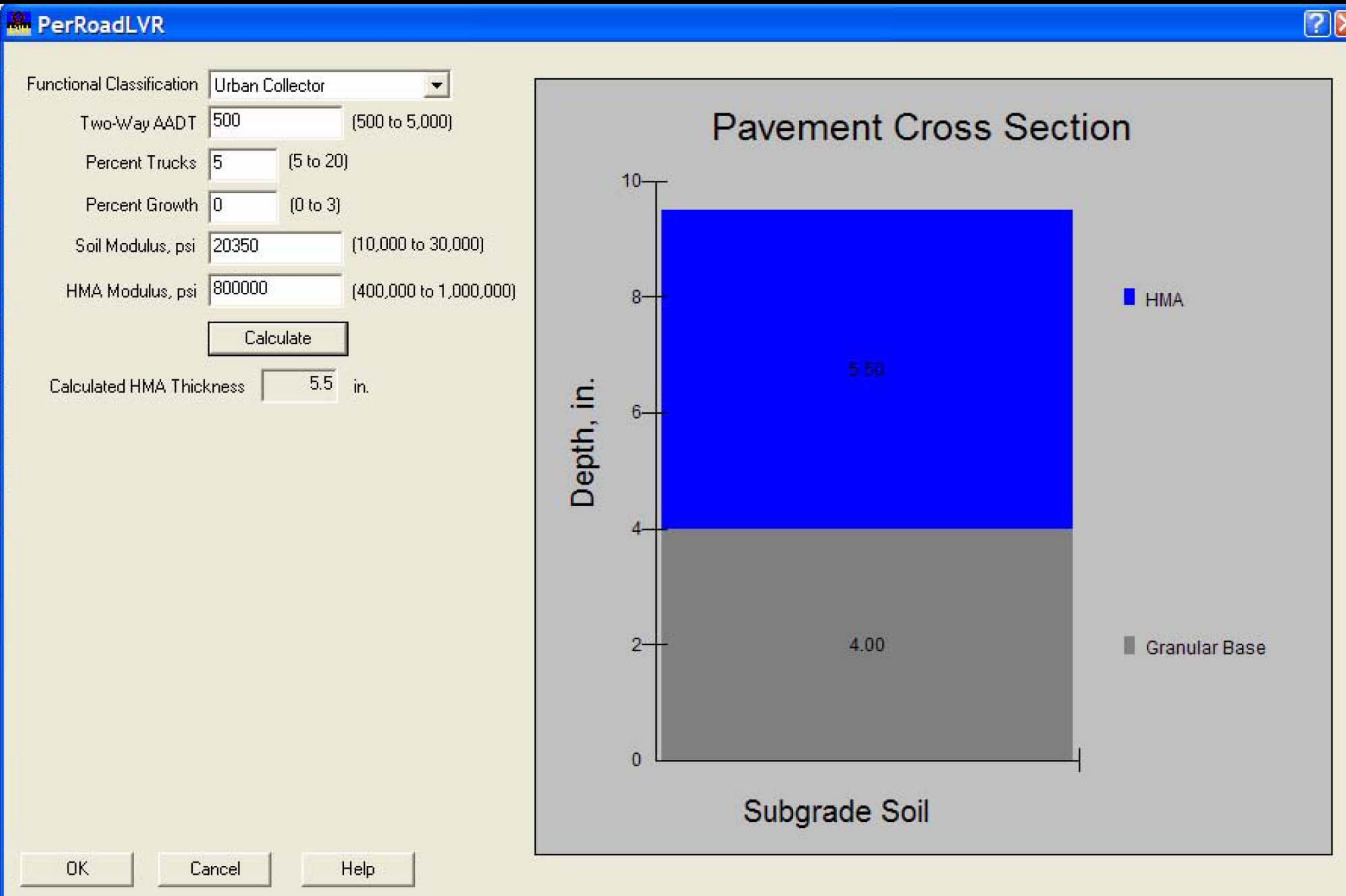
NAPA

Design Equation

$$HMA = C_0 + C_1*AADT + C_2*\%Trucks + C_3*\%Growth + C_4*Soil\ Stiffness + C_5*HMA\ Stiffness$$

Coefficient	Urban Collector	Rural Local Collector
C_0	10.963	11.963
C_1	6.661E-4	6.753E-4
C_2	0.120	0.124
C_3	0.258	0.234
C_4	-1.150E-4	-1.276E-4
C_5	-5.071E-6	-5.486E-6
R^2	0.942	0.938

PerRoad LVR


PerRoadLVR
Functional Classification
Urban Collector
Two-Way AADT
500
(500 to 5,000)
Percent Trucks
5
(5 to 20)
Percent Growth
0
(0 to 3)
Soil Modulus, psi
20350
(10,000 to 30,000)
HMA Modulus, psi
800000
(400,000 to 1,000,000)
Calculate
Calculated HMA Thickness
5.5
in.
OK
Cancel
Help
Pavement Cross Section
Depth, in.
10
8
6
4
2
0
5.50
4.00
HMA
Granular Base
Subgrade Soil

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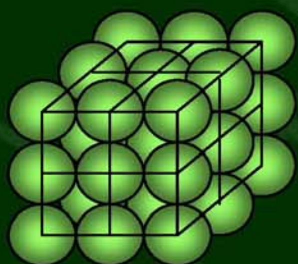
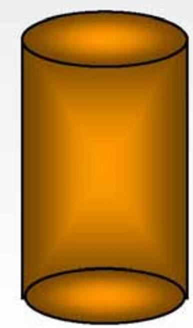


Resilient Modulus Prediction Models for Fine-Grained Soils in Ohio: Preliminary Study

ICPP
Sept. 14, 2006
Columbus, OH



Teruhisa Masada, PhD
Associate Professor
Department of Civil Engineering
Ohio University

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Summary/Conclusions – Page 3

- Linear relationship between resilient modulus and octahedral stress ratio in logarithmic scale
- Five stress (power, bilinear, hyperbolic, semi-log, octahedral) models evaluated in light of the latest laboratory test data
- Hyperbolic model may be the most reliable. Deviatoric stress alone can adequately express the resilient behaviors of the A-4 soil samples.

Final Comment

- AASHTO Universal Model

$$M_R = k_1 p_a \left(\frac{\theta}{p_a} \right)^{k_2} \left(\frac{\tau_{oct}}{p_a} + 1 \right)^{k_3}$$

May not be a good model for fine-grained soils
Since this model does not have the deviatoric
Stress (σ_d) as one of its parameters.

Mix Type Selection for Perpetual Pavements

NATIONAL ASPHALT PAVEMENT ASSOCIATION

International Conference on Perpetual Pavements
Columbus, Ohio
September 14, 2006

Recommendations for Base

- Dense, Fine
  - 19 – 37.5 mm
  - Lift Thickness 3 to 4X NMAS
  - All Traffic
- Dense, Coarse
  - 19 – 37.5 mm
  - Lift Thickness 4 to 5X NMAS
  - All Traffic
- ATPB
  - 19 – 37.5 mm
  - Lift Thickness 2 to 4X NMAS
  - High Traffic

Recommendations for Intermediate

- Dense, Fine
  - 19 – 25 mm
  - Lift Thickness 3 to 4X NMAS
  - All Traffic Levels
- Dense, Coarse
  - 19 – 25 mm
  - Lift Thickness 4 to 5X NMAS
  - All Traffic Levels

Recommendations for Surface

- Dense, Fine
  - 4.75 – 19 mm
  - Lift Thickness 3 to 4X NMAS
  - All Traffic Levels
- Dense, Coarse
  - 9.5 – 19 mm
  - Lift Thickness 4 to 5X NMAS
  - High Traffic

Recommendations for Surface (cont.)

- SMA
  - 9.5 – 19 mm
  - Lift Thickness 2.5 to 4X NMAS
  - Highly recommended for High Vol.
  - Mod. recommendation for Med. Vol.
- OGFC
  - 9.5 – 12.5 mm
  - Lift Thickness 2 to 3X NMAS
  - Recommended for High Vol.

Perpetual Pavement Evaluation Using the Viscoelastic Continuum Damage Finite Element Program

Y. Richard Kim, Shane Underwood
Sungho Mun, Murthy Guddati
North Carolina State University

Presented at
The International Conference on Perpetual Pavement
September 14, 2006

VEPCD-FEP++ Research at NCSU

- Goal
  - Develop a comprehensive mechanistic model capable of accurately describing asphalt concrete pavement response and performance, including fatigue cracking (both bottom-up and top-down), rutting, and thermal cracking, under moving wheel loads.

MultiSmart3D - The Next Generation Algorithm for Pavement Design

Ernie Pan

Computer Modeling & Simulation Group

Dept. of Civil Engineering

Dept. of Applied Mathematics

University of Akron, Ohio

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International Conference on Perpetual Pavement
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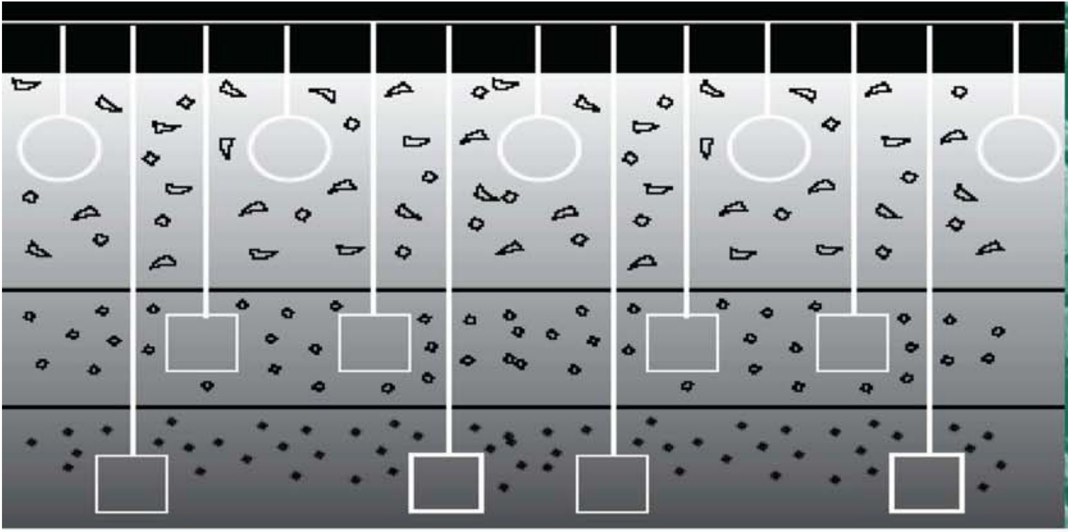
Current Limitations of Elastic Layered Pavement Analysis

- **Modulus Variation with Depth is Averaged.**
- **Limited Number of Elastic Layers.**
- **Classic Contact Pressure Assumptions:**
  - **Equal to Inflation Pressure**
  - **Uniform Distribution**
- **Geometry of Loaded Area:**
  - **Circular Loaded Area**
  - **Axial Symmetry**

*Multi**Smart3D*** Program



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Hilton Columbus at Easton,
Columbus, Ohio

Multi-Body Dynamic Modeling of the Expected Performance of Accelerated Pavement Testing Facilities

prof. Ezio Santagata
Politecnico di Torino - Italy

International Conference on Perpetual Pavements

Columbus, Ohio

September 14, 2006

Application of the Endurance Limit in M-E Pavement Design

Harold L. Von Quintus, P.E.

APPLIED RESEARCH ASSOCIATES, INC.®
An Employee-Owned Company

Fatigue Characteristics of Rich Bottom Bases (RBB) for Structural Design of Perpetual Pavements

Conclusions / Findings

- **RBB procedure increases flexural modulus**
  - Extra 0.5% binder, 3-4% air voids
  - Laboratory handling may influence also
- **RBB procedure improves the fatigue equation**
  - Impact of these modifications may be considered marginal until investigated further

Conclusions / Findings

- **Fatigue Endurance Limit (FEL) exists**
  - Strain below which extended fatigue life is found
- **FEL varies with flexural modulus**
  - Larger FEL strain at lower modulus
    - Is this a mixture effect?
    - Is this a binder effect?
- **The Same FEL was found for standard and RBB mixtures**
  - Binder type primarily responsible for FEL strain limit, not mixture changes

Conclusions / Findings

- Healing potential (binder molecular chemistry) offsets damage at low strain values.
  - Polymer modification can increase the FEL strain limit
- Healing is active at all times during the loading – unloading cycle in a fatigue test, and in the field, not just rest periods between load pulses.

Endurance Limit of HMA Mixtures

Brian Prowell
Ray Brown

National Center for Asphalt Technology
NCAT
AUBURN UNIVERSITY

Objectives

- Confirm existence of Endurance Limit
- Effect of Material Properties on Endurance Limit
- Shortcut method to determine Endurance Limit
- Suggested changes to design guide to include Endurance Limit

Conclusions

- 500 million load repetitions is a practical maximum for 40 years of traffic
- Thus, considering a shift factor of 10, 50 million cycles in the lab approximates the maximum number of load repetitions
- The single-stage Weibull function offers a conservative approach to extrapolate fatigue stiffness data

Conclusions (Continued)

- There is an endurance limit
- An average endurance limit of approximately 150 micro-strain was indicated for the PG 64-22 mix; 225 micro-strain for the PG 76-22 mix
- Optimum plus asphalt content may increase the endurance limit slightly

CONSIDERING HOT-MIX –ASPHALT FATIGUE ENDURANCE LIMIT IN FULL-DEPTH M-E PAVEMENT DESIGN

Marshall R. Thompson
Samuel H. Carpenter

Department of Civil Engineering
University of Illinois @ U-C

CONFERENCE SUMMARY

- Perpetual Pavements are a world-wide phenomena, being designed and built around the globe
- A fatigue endurance limit (FEL) does exist. It is mix dependent, mostly related to the binder used
- The FEL can be practically determined in the laboratory
- Various analyses are available to effectively design perpetual pavements

CONFERENCE SUMMARY

- Enough pavements have been instrumented to verify that they can be reliably designed and built so as to not exceed the FEL
- Existing roadway networks can be assessed to determine which pavements are perpetual, upgradable to perpetual or determinate life
- Practicable guidelines exist to select proper mixes for perpetual pavements
- Practicable guidelines exist to apply the perpetual pavement concept to low volume roads