Accelerated Pavement Testing Update

Joe P. Mahoney
University of Washington
Topics

- National and international APT committees and conferences
- Accelerated pavement testing
  - Earlier APT Tests
  - Characteristics of APT facilities
  - Examples of international APT facilities and results
  - Examples of national APT facilities and results
- Concluding remarks
• Gregers Hilderbrand, Chair COST 347

• “The main objective of the Action is to develop a European code of good practice to optimize the use of Accelerated Load Testing facilities and improve the application of results from these facilities.”

• 16 COST Countries: Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, The Netherlands, Romania, Slovenia, Spain, Sweden, Switzerland and the United Kingdom.
• Concerned with full-scale testing of pavements by the use of conventional traffic loading and/or the application of accelerated loading.

• Full-scale and accelerated testing includes all traditional pavement types and materials as well as new and innovative approaches, and may be carried out under laboratory or field conditions using mobile or fixed equipment or conventional traffic.
HVSIA

• HVS International Alliance
  - Finland
  - Sweden
  - South Africa
  - USA (California, Florida, WES, CRREL)

• Objectives
  - Promote and share knowledge related to HVS technology;
  - Establish a structure for ongoing interactions on topics related to pavement engineering with a specific focus on the HVS technology;
  - Establish mechanisms for funding, monitoring and completing studies of common issues through the optimum participation of members;
  - Provide expertise so that studies of interest can be expeditiously defined, managed and results reviewed;
  - Optimize the use of resources through the coordination of HVS related research.
# HVSIA Example Activity Matrix—1

<table>
<thead>
<tr>
<th>Operator</th>
<th>Structural Design</th>
<th>Materials</th>
<th>Perf</th>
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<th>Construction</th>
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**Significant Enhancements for Pavement Knowledge and Practice**
HVSIA Example Activity Matrix—2

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Significant Enhancements for Pavement Knowledge and Practice
## Actual HVSIA Activity Matrix—2006

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<th>F - Florida</th>
<th>CR - CRREL</th>
<th>V - Finland/Sweden</th>
<th>C - Coltrons</th>
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<tr>
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<td><strong>Competency Areas</strong></td>
<td><strong>Performance</strong></td>
<td><strong>Rehab/Mont</strong></td>
<td><strong>Focus Areas</strong></td>
<td><strong>Competency Areas Continued</strong></td>
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<td><strong>Focus Areas (continued)</strong></td>
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<td><strong>Performance</strong></td>
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HVSIA matrix of research done by Cal APT for the topic of “long lasting pavements—rehab and maintenance”

<table>
<thead>
<tr>
<th>Title</th>
<th>Report / Tech Memo No.</th>
<th>Authors</th>
<th>Date of issue</th>
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<tr>
<td>Reports</td>
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<tr>
<td>Economic Implications of Selection of Long-Life versus Conventional Caltrans Rehabilitation Strategies for High-Volume Highways</td>
<td>Not Assigned</td>
<td>Jones, D., C. Lee, and J. Harvey</td>
<td>Jun-05</td>
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<td>Characterization of Effective Built-In Curling and Concrete Pavement Cracking on the Palmdale Test Sections</td>
<td>Not Assigned</td>
<td>Roe, S., and J. Roessler</td>
<td>May-03</td>
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<td>Analysis and Estimation of Effective Built-In Temperature Difference for North Tangent Slabs: Data Analysis from the Palmdale, California High Pavement</td>
<td>Not Assigned</td>
<td>Roe, S. and J. Roessler</td>
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<td>Environmental Influences on the Curling of Concrete Slabs at the Palmdale HVS Test Site</td>
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<td>Pessis, I. and J. Harvey</td>
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<td>Alkali Reaction Results on Fast-Setting Hydraulic Cement Concrete, Palmdale, California Test Sections, South Tangent</td>
<td>Not Assigned</td>
<td>Gi, Pless, L. D. Bush, R. Joosten, D. Hump, C. Scheffy, J. Roessler, I. Popepaul, J. T. Harvey</td>
<td>Jul-02</td>
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<td>Accelerated Laboratory Testing for High Early Strength Concrete for Alkali Aggregate Reaction</td>
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<td>Shorgin, K., Martinec, P., and Harvey</td>
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<td>Accelerated Test for Measuring Sulfate Resistance of Hydraulic Cement for Caltrans LLRIS Program</td>
<td>Not Assigned</td>
<td>Montes, J., K. Roessler, and J. T. Harvey</td>
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<td>Assessing the Economic Benefits from the Implementation of New Pavement Construction Methods</td>
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<td>Gilfeir, D., J. T. Harvey, D. Cooper, and D. Hump</td>
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<td>Con tortuability Analysis for Long Life Concrete Pavement Rehabilitation Strategies</td>
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<td>Roessler, J. K., J. T. Harvey, J. Parker, and P. Long</td>
<td>Feb-00</td>
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<td>Shrinkage and Thermal Cracking of Fast Setting Hydraulic Cement Concrete Pavements in Palmdale, CA</td>
<td>Not Assigned</td>
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<td>Technical Memos</td>
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<td>Evaluation of 1-60 Long-Life Corridor Costs</td>
<td>TRM-UCB-PRE-2005-4</td>
<td>Santero, W. Nokes, and J. Harvey</td>
<td>Jun-05</td>
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CAPT

- Consortium on Accelerated Pavement Testing
  - California
  - Louisiana
  - FHWA
  - Texas
  - Kansas
  - Illinois
  - Minnesota
  - Ohio
  - Texas
  - Indiana
  - TRB AFD40
  - NCAT

- Objectives
  - Organize and structure a program that identifies and produces key technical deliverables.
  - Provide a means to define, support and share APT technology of mutual interest.
  - Develop a longer-range plan of collaboration (strategic plan), including potential cooperation with international community.
  - Provide for special studies, investigations, research and training.
APT Conferences


• Third International Conference on Accelerated Pavement Testing, Madrid, Spain, October 1-3, 2008.

• Numerous APT conferences have been held over the last 20+ years in countries such as South Africa (including 7 Conferences on Asphalt Pavements for Southern Africa)
Significant National Publications


Let us look back on earlier APT efforts
U.S. Test Roads 1950-1961

- Road Test One-MD, 1950-1951, HRB directed project (rigid pavement only)

- WASHO Road Test, 1952-1954, HRB directed project (flexible pavement only)

- AASHO Road Test, 1956-1961, HRB directed project (originally planned for 1951 but modified, in part, due to WASHO Road Test)
Motivation behind these test roads?

- Increasing truck and bus volumes
- Increasing axle loads, in part, due to switch from solid rubber to pneumatic tires in 1920s. Also dual tires came into use.
  - 1932: AASHO recommended 16,000 lb single axles
  - 1942: AASHO recommended during WWII 18,000 lb single axles
  - 1946: AASHO recommended
    - 18,000 lb single axles
    - 32,000 lb tandem axles
WASHO Road Test

HIGHWAY RESEARCH BOARD
Special Report 22

The WASHO Road Test
PART 2: TEST DATA, ANALYSES, AND FINDINGS

1955
Washington, D. C.
WASHO Road Test

- Flexible pavements only
- Constructed summer 1952
- Testing complete May 1954
- Asphalt concrete either 50 mm or 100 mm thick
- Total structural section thicknesses ranged from 150 mm to 550 mm
- Two loops, four test lanes with a total of 46 test sections
- Total Cost: $650,000 (states paid 64% of the total)
WASHO Road Test Findings

- Freeze-thaw effects were significant
- Construction variability noted
- Performance of thicker AC superior
- Extensive use of pavement deflections (development of the Benkelman Beam)
- Deflection measurements led to development of AC overlay design process
- Benefit of paved shoulders
- Damaging effects of various axle loads and configurations and early equivalency results
  - 18 kip single axle ⇒ 30 kip tandem axle
  - 22.4 kip single axle ⇒ 40 kip tandem axle
AASHO Road Test
“The Ultimate APT Experiment”

The AASHO Road Test
History and Description of Project

National Academy of Sciences—
National Research Council
AASHO Road Test Findings

- Layer and load equivalencies developed.
- Construction variability quantified.
- Showed that pavements could be designed to carry high volumes of heavy loads.
- AASHO design equation in effect an early performance equation.
- Showed impact of spring thaw on performance!
- Benefits associated with thick AC and PCC slabs.
AASHO Road Test Findings

- Stimulated pavement research (national and state).
- Benefit of controlled loading—the data has been an invaluable R&D resource for almost 5 decades!
## Cost Comparison Per Test Section

<table>
<thead>
<tr>
<th>Road Test</th>
<th>Original Cost</th>
<th>Inflation Adjusted (2006)</th>
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<tr>
<td>WASHO Road Test (1952)</td>
<td>$14,000</td>
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<tr>
<td>AASHO Road Test (1958)</td>
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Characteristics of APT Facilities

- APT programs
- Implementation of APT results
- Costs
# APT Programs

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<td>Total Active APT Programs Worldwide</td>
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<tr>
<td>Total Active APT Programs in the US</td>
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## Type of APT Application

<table>
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<th>Type of APT Application</th>
<th>Number of APT Programs</th>
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<td>Laboratory</td>
<td>8</td>
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<tr>
<td>Fixed Site</td>
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<td>In-Service Pavement</td>
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<td>Test Roads</td>
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<td>Specially Constructed</td>
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*Includes double counting of APT programs.*
## Implementation of APT Results are Geared Towards?

<table>
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<th>Type of Implementation</th>
<th>Number of APT Programs*</th>
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<td>Pavement Structural Composition</td>
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<td>Loading-Environment (Traffic/Climate)</td>
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<td>Materials and Tests</td>
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<tr>
<td>Performance Models</td>
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<td>Construction Techniques</td>
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<tr>
<td>Rehabilitation Strategies</td>
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*Includes double counting of APT programs.

Source: Hugo and Epps-Martin, 2002
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<th>Number of APT Programs</th>
<th>Capital Cost of APT Facility Equipment ($ million)</th>
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<td>2.0-5.0</td>
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<td>6</td>
<td>Greater than 5.0</td>
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Yearly APT Budget without Pavement Construction Costs

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<td>3</td>
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## Average Operational Cost per Test Section

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### Cost Comparison Per Test Section—Another View

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<th>Inflation Adjusted (2006)</th>
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<tr>
<td>WASHO Road Test</td>
<td>$14,000</td>
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<td>LTPP</td>
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Examples of International APT Facilities
South Africa HVS

HVS development started in 1971
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<td>HVS APT: 1979</td>
<td><img src="image1" alt="Before Image" /></td>
<td><img src="image2" alt="After Image" /></td>
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<tr>
<td>LTPP: 1994</td>
<td><img src="image3" alt="Before Image" /></td>
<td><img src="image4" alt="After Image" /></td>
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</tbody>
</table>
LCPC—France

LCPC program started in 1978
HVS Nordic—Finland and Sweden

HVS Nordic program started in 1998
CEDEX—Spain

(CEntro De Estudios De Carreteras Test Facility)

CEDEX program started in 1987
New Zealand CAPTIF

Canterbury Accelerated Pavement Testing Indoor Facility

CAPTIF program started in 1987
Summary International APT

• International APT programs have typically been underway for about 20 years.
• Design-build-operate pavement tests.
• Warranties.
Examples of National APT Facilities
MnROAD Experiment

Mn/Road program started in 1993
NCAT Test Track

NCAT Test Track Started in 1996
USACOE Accelerated Pavement Testing

HVS “Bigfoot” started 1998
Louisiana Transportation Pavement Research Facility (ALF)

Louisiana ALF program started in 1995
Louisiana ALF Studies

• Development of cracking models.
• Investigation of rubberized asphalt pavement performance.
• Investigation of inverted pavements using recycled asphalt pavement.
• APT is necessary in order to rapidly investigate materials and design.
Florida DOT
Accelerated Pavement Testing and Research Program
(Program started in 1999. First loads applied October 2000)
Florida DOT HVS Results

Initial Rut Comparison
67-22 (Unmodified) vs. 76-22 (Modified) Binders

![Graph showing comparison between 67-22 (Unmodified) and 76-22 (Modified) Binders regarding rut depth and number of passes.](image)

- **Rut Depth (mm)**
- **Number of Passes (9000 pound load)**

- 76-22 Binder (Modified)
- 67-22 Binder (Unmodified)
California Heavy Vehicle Simulator

Cal APT program started in 1994
Ukiah, CA
Dowel Bar Retrofit

Richmond Field Station
UC Berkeley
Drainable Bases, Bonding of AC Layers, etc.
SR 14 Palmdale, California
California HVS Results

- Benefits of adequate tack coats between HMA layers.
- Relationship between compaction and cracking.
- Performance of rubber-asphalt mixes—good.
- Performance of stabilized permeable layers—poor.
- Benefits of dowel bars in PCC and retrofitting dowel bars in existing slabs—good.
- Flexible pavement performance models.
Summary U.S. APT

- U.S. based APT programs have typically been underway for about 10 years.
- APT more directed toward Federal and State DOT pavement issues.
- Extensive performance modeling.
- Examination of (for example):
  - Tack coats
  - Binders and modifiers
  - Pavement systems
  - Drainage layers
Summary

• APT programs have produced significant pavement findings over a period of at least 30 years.

• Outstanding APT countries and states

  • South Africa
  • France
  • Finland and Sweden
  • Spain
  • Australia

  • Florida
  • California
  • Minnesota
  • Alabama (NCAT)
  • Louisiana
Summary—My View

• Detailed gains in knowledge about pavements will be largely advanced via APT activities over the next several decades.

• The national APT programs have formed a “Consortium on Accelerated Pavement Testing (CAPT)” to better coordinate their activities.

• APT and LTPP activities should merge—do both and do them together.
There may be some roads for which APT is not needed—at least at this point in time.
APT Update

Questions?