Accelerated Pavement Testing Update

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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

COST 347

- 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.

TRB Committee AFD40

- 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

Operator	Structural Design	Materials	Perf	Rehab	Construction	Info Systems and Training
RSA		√		√		
CA	√	√				
FL		√	√			
WES	√	√			√	√
VTI/VTT	√			√		
CRREL		√			√	

Significant Enhancements for Pavement Knowledge and Practice

HVSIA Example Activity Matrix—2

Operator	Structural Design—Long Lasting	WAM Paving	Specs/ Contracts	New Rehab Strategies	Construct Variables	Deep Recycled Systems
RSA		√		√		
CA	√	√				
FL		√	√			
WES	√	√			√	√
VTI/VTT	√			√		
CRREL		√			√	

Significant Enhancements for Pavement Knowledge and Practice

Actual HVSIA Activity Matrix—2006

R = RSA/Gautrans E = Corp of Engineers F = Florida CR = CRREL V = Finland/Sweden C = Caltrans

Focus Areas	Competency Areas																			Focus Areas	Competency Areas Continued																
	Struc Des			Materials					Performance						Rehab/Maint						Constr			Info Syst			VPI			Instr				EIA
									Func		Struc																										
Asphalt	R	C	V	F	C	R	V	CR	R	C	F	R	C	CR	E	R	V	C	Asphalt		R	C	C				F	C	R	F	CR	C	R	CR
Cemented layers	R	C	E		E	R	C		R		E	R				R			Cemented layers	E	R														
Concrete	R	C			C	R			R		F	R	C		E	R	F	C	Concrete	F	R	C	C						F	CR	C	R	
Granular	R	C	V			R	V	CR		C									Granular	CR	R									E			CR
Modified binders		C		F	C			CR		C	F		C					C	Modified binders	F		C	C			F			F				CR
LIC	R					R						R				R			LIC		R												
Long lasting pvmts		C			C					C			C					C	Long lasting pvmts			C	C								C		
NDT		C									E		C		E			C	NDT	E			C										
LTPP																			LTPP														
Surface Treatments											E								Surface Treatments														

R = RSA/Gautrans E = Corp of Engineers F = Florida CR = CRREL V = Finland/Sweden C = Caltrans

Focus Areas (continued)	Competency Areas																			Focus Areas (continued)	Competency Areas (continued)																
	Struc Des			Materials					Performance						Rehab/Maint						Construct.			Info Syst			VPI			Instr				EIA
									Func		Struc																										
Bitumen/polymer stab	R		E		E	R					E	R	C		E	R		C	Bitumen/polymer stab	E	R														
DISR	R	C			C	R			R	C			C			R		C	DISR		R	C	C									C		
Upgrading of LVRs	R		CR			R		CR				R		CR		R	CR		Upgrading of LVRs	R										CR			CR
Roadbed prep																			Roadbed prep														
Waste materials	R	C			C	R		CR		C		R	C	CR				C	Waste materials			C	C								C		CR
Subgrade soils		C	V		C			CR		C		V	C	CR					Subgrade soils	CR			C							E	C		CR
Geosynthetics	E		V		E			CR			E			CR					Geosynthetics											CR			CR
Unpaved roads					E				E										Unpaved roads														
Side Slopes												V							Side Slopes											V			
Light weight material							V					V							Light weight material														
Comparative testing																			Comparative testing													R	

HVSIA matrix of research done by Cal APT for the topic of "long lasting pavements—rehab and maintenance"

Title	Report / Tech Memo No.	Authors	Date of issue
Reports			
Economic Implications of Selection of Long-Life versus Conventional Caltrans Rehabilitation Strategies for High-Volume Highways	Not Assigned	Jones, D., C. Lee, and J. Harvey	Jun-05
Characterization of Effective Built-in Curling and Concrete Pavement Cracking on the Palmdale Test Sections	Not Assigned	Rao, S., and J. Roesler	May-05
Accelerated Laboratory Testing for Alkali-Silica Reaction Using ASTM 1293 and Comparison with ASTM 1260	Not Assigned	Carlos, C. Jr., M. Mancio, K. Shomglin, J. T. Harvey, P. Monteiro, and A. Ali	Nov-04
Palmdale South Tangent Built-In Curling and Cracking: Preliminary Analysis Report	Not Assigned	Rao, S. and J. Roesler	May-04
Analysis and Estimation of Effective Built-In Temperature Difference for North Tangent Slabs: Data Analysis from the Palmdale, California Rigid Pavement	Not Assigned	Rao, S. and J. Roesler	May-04
Goal 4 Long Life Pavement Rehabilitation Strategies--Rigid: Laboratory Strength, Shrinkage, and Thermal Expansion of Hydraulic Cement Concrete Mixes	Not Assigned	Zhang, J., J.T. Harvey, A. Ali, and J. Roesler	Feb-04
Environmental Influences on the Curling of Concrete Slabs at the Palmdale HVS Test Site	Not Assigned	Plessis, L and J. Harvey	Jun-03
HVS Test Results on Fast-Setting Hydraulic Cement Concrete, Palmdale, California Test Sections, South Tangent	Not Assigned	du Plessis, L., D. Bush, F. Jooste, D. Hung, C. Scheffy, J. Roesler, L Popescu, J. T. Harvey	Jul-02
Accelerated Laboratory Testing for High Early Strength Concrete for Alkali Aggregate Reaction	Not Assigned	Shomglin, K., Monteiro, P., and Harvey, J.	Jul-01
Case Study of Urban Concrete Pavement Reconstruction and Traffic Management for the I-10 (Pomona, CA) Project	Not Assigned	Lee, E. B., J. R. Roesler, J. T. Harvey, and C. W. Ibbs.	Jan-01
CAL/APT Program Summary Report Six Year Period: 1994-2000	FHWA/CA/RM-2000/15	Harvey, J. T., J. Roesler, N. F. Coetzee, and C. L. Monismith	Jun-00
Preliminary Evaluation of Proposed LLPRS Rigid Pavement Structures and Design Inputs	FHWA/CA/OR-2000/02	Harvey, J. T., J. Roesler, J. Farver, and L. Liang	May-00
Accelerated Test for Measuring Sulfate Resistance of Hydraulic Cements for Caltrans LLPRS Program	Not Assigned	P. Monteiro, J. Roesler, K.E. Kurtis and J.T. Harvey	Apr-00
Assessing the Economic Benefits from the Implementation of New Pavement Construction Methods	Not Assigned	Gillen, D., J. T. Harvey, D. Cooper, and D. Hung	Mar-00
Investigation of Design and Construction Issues for Long Life Concrete Pavement Strategies	FHWA/CA/OR-2000/02	Roesler, J. R., J. T. Harvey, J. Farver, and F. Long	Feb-00
Constructability Analysis for Long Life Concrete Pavement Rehabilitation Strategies	FHWA/CA/OR-2000/01	Lee, E., W. Ibbs, J. Harvey, and J. Roesler	Feb-00
Shrinkage and Thermal Cracking of Fast Setting Hydraulic Cement Concrete Pavements in Palmdale, CA	Not Assigned	Heath, A. C. and J. R. Roesler	Dec-99
CAL/APT Goal LLPRS - Rigid Phase III: Concrete Test Section 516CT Report	Not Assigned	Roesler, J., L. du Plessis, D. Hung, D. Bush, J. Harvey	Apr-99
Analysis of Durability of Advanced Cementitious Materials in Rigid Pavement Construction in California	Not Assigned	K.E. Kurtis and P. Monteiro	Apr-99
Technical Memos			
Evaluation of I-15 Devore (08-0A4224) Long-Life Pavement Rehabilitation Costs	TM-UCB-PRC-2005-8	Fermo, M.G., N. Santero, W. Nokes, and J. Harvey	Jun-05
Evaluation of I-710 Long Beach (07-1384U4) Long-Life Pavement Rehabilitation Costs	TM-UCB-PRC-2005-6	Harvey, J, N. Santero, H. Lee, W. du Toit, M. G. Fermo	Jun-05
Evaluation of I-10 Pomona (07-181304) Long-Life Pavement Rehabilitation Costs	TM-UCB-PRC-2005-5	Harvey, J, N. Santero, M. G. Fermo	Jun-05
Evaluation of I-80 Long-Life Corridor Costs	TM-UCB-PRC-2005-4	Santero, N., W. Nokes, and J. Harvey	Jun-05
Fast-Track Urban Freeway Rehabilitation with 55-hour Weekend Closures: I-710 Long Beach Case Study	TM-UCB-PRC-2004-4	Lee, E. B., H. Lee, and J. T. Harvey	Mar-04

CAPT

- Consortium on Accelerated Pavement Testing
  - California
  - Louisiana
  - FHWA
  - Texas
  - Kansas
  - Illinois
  - Ohio
  - Minnesota
  - 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

- First International Conference on Accelerated Pavement Testing, Reno, Nevada, October 18-20, 1999.
- Second International Conference on Accelerated Pavement Testing, Minneapolis, MN, September 19-22, 2004.
- 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

- NCHRP Synthesis 325 (2004), “Significant Findings from Full-Scale Accelerated Pavement Testing.”
- NCHRP Report 512 (2003), “Accelerated Pavement Testing: Data Guidelines.”
- NCHRP Synthesis 235 (1996), “Application of Full-Scale Accelerated Pavement Testing.”


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

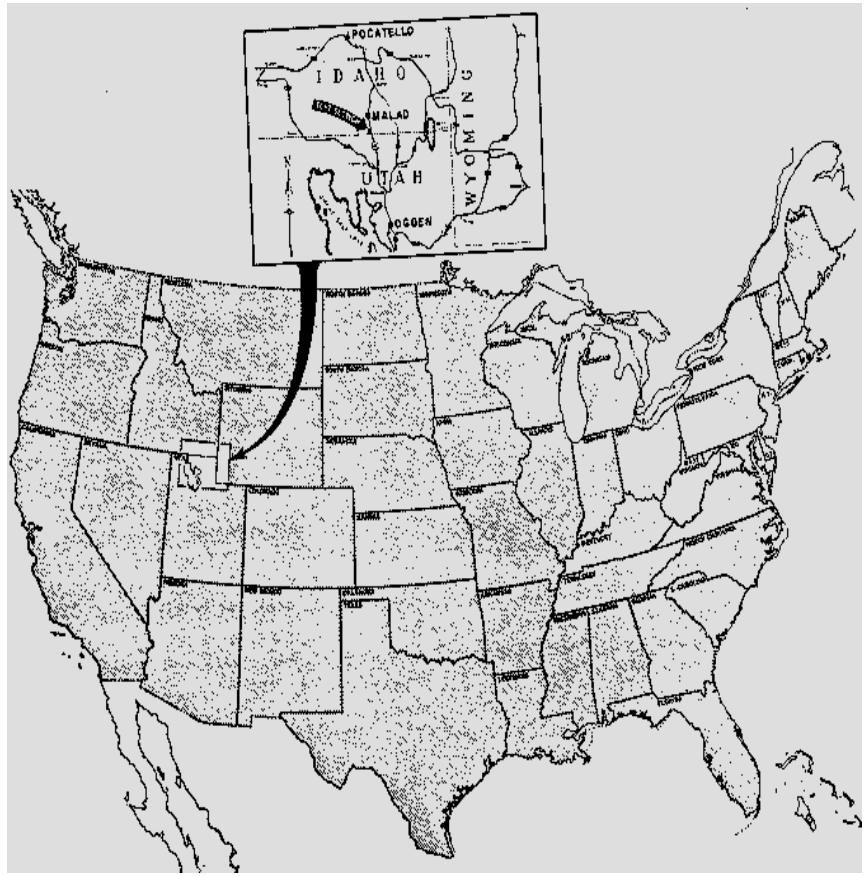
Special Report 22

The WASHO Road Test

PART 2: TEST DATA, ANALYSES, AND FINDINGS

1955

Washington, D. C.



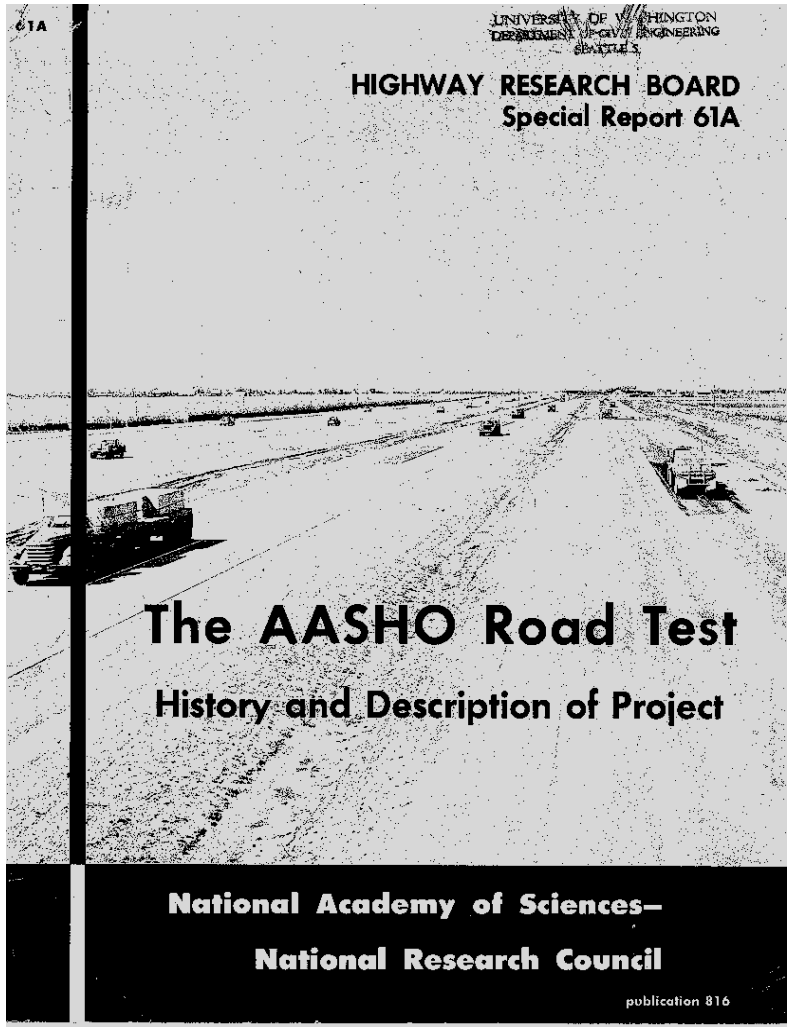
WASHO Road Test

- 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 $\Rightarrow$ 30 kip tandem axle
  - 22.4 kip single axle $\Rightarrow$ 40 kip tandem axle

AASHO Road Test
“The Ultimate APT Experiment”



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

Road Test	Original Cost	Inflation Adjusted (2006)
WASHO Road Test (1952)	$14,000	$106,000
AASHO Road Test (1958)	$32,000	$221,000

Characteristics of APT Facilities

- APT programs
- Implementation of APT results
- Costs

APT Programs

APT Programs	Active
Total Active APT Programs Worldwide	28
Total Active APT Programs in the US	15

Type of APT Application

Type of APT Application	Number of APT Programs
Field	9
Laboratory	8
Fixed Site	20
In-Service Pavement	4
Test Roads	5
Specially Constructed	18

*Includes double counting of APT programs.

Implementation of APT Results are Geared Towards?

Type of Implementation	Number of APT Programs*
Pavement Structural Composition	27
Loading-Environment (Traffic/Climate)	19
Materials and Tests	25
Performance Models	22
Construction Techniques	14
Rehabilitation Strategies	18

*Includes double counting of APT programs.

Source: Hugo and Epps-Martin, 2002

Capital Cost of APT Facility Equipment

Number of APT Programs	Capital Cost of APT Facility Equipment ($ million)
5	Less than 1.0
8	1.0-2.0
6	2.0-5.0
6	Greater than 5.0

Yearly APT Budget without Pavement Construction Costs

Number of APT Programs	Annual Program Cost ($ million)
3	Less than 0.1
7	0.1-0.2
4	0.2-0.4
3	0.4-0.8
5	0.8-1.0
3	Greater than 1.6

Average Operational Cost per Test Section

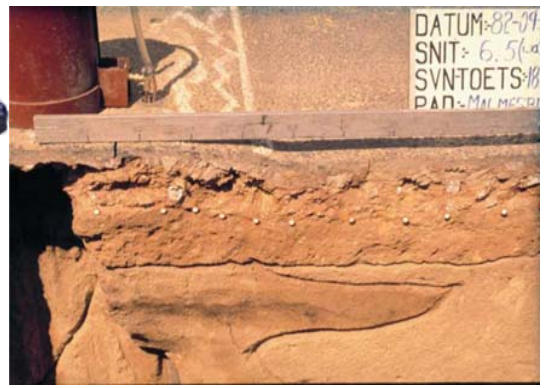
Number of APT Programs	Cost/Test Section ($ million)
21	Less than 0.5
3	0.5-1.0
1	1.0-2.0

Cost Comparison Per Test Section—Another View

Road Test	Original Cost	Inflation Adjusted (2006)
WASHO Road Test	$14,000	$106,000
LTPP	$125,000	$136,000
AASHO Road Test	$32,000	$221,000
WesTrack	$560,000	$610,000

Examples of International APT Facilities

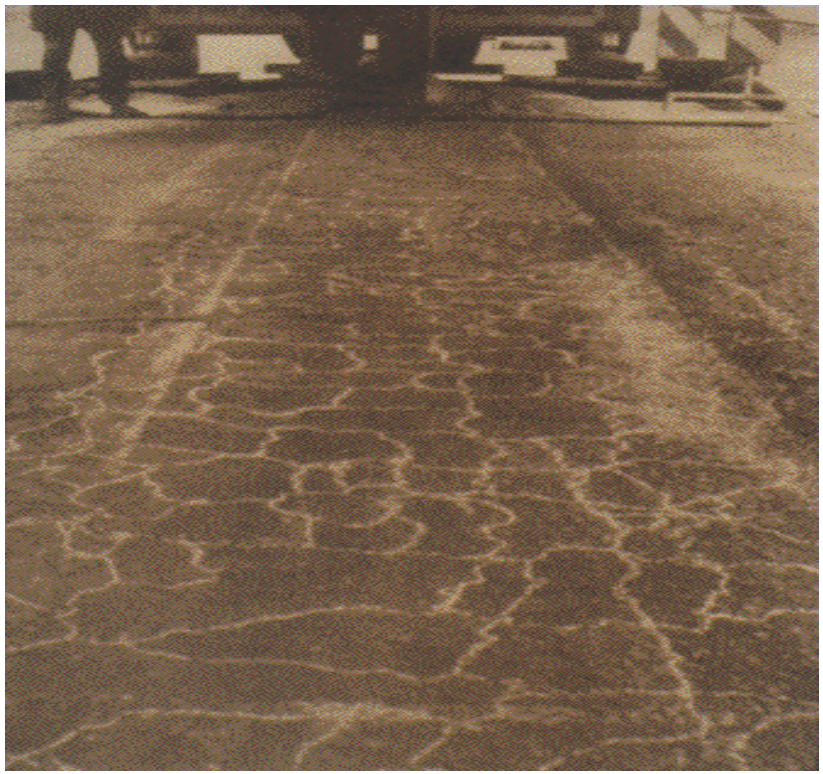
South Africa HVS



HVS development started in 1971

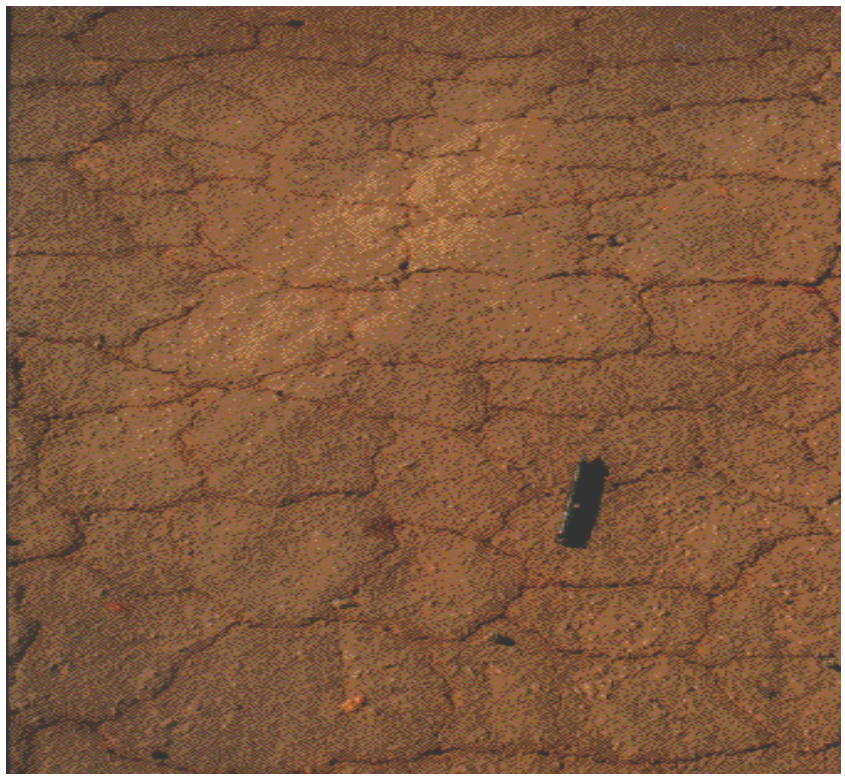
South Africa Comparison of APT and LTPP Sections

Before



HVS APT:1979

After



LTPP: 1994

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

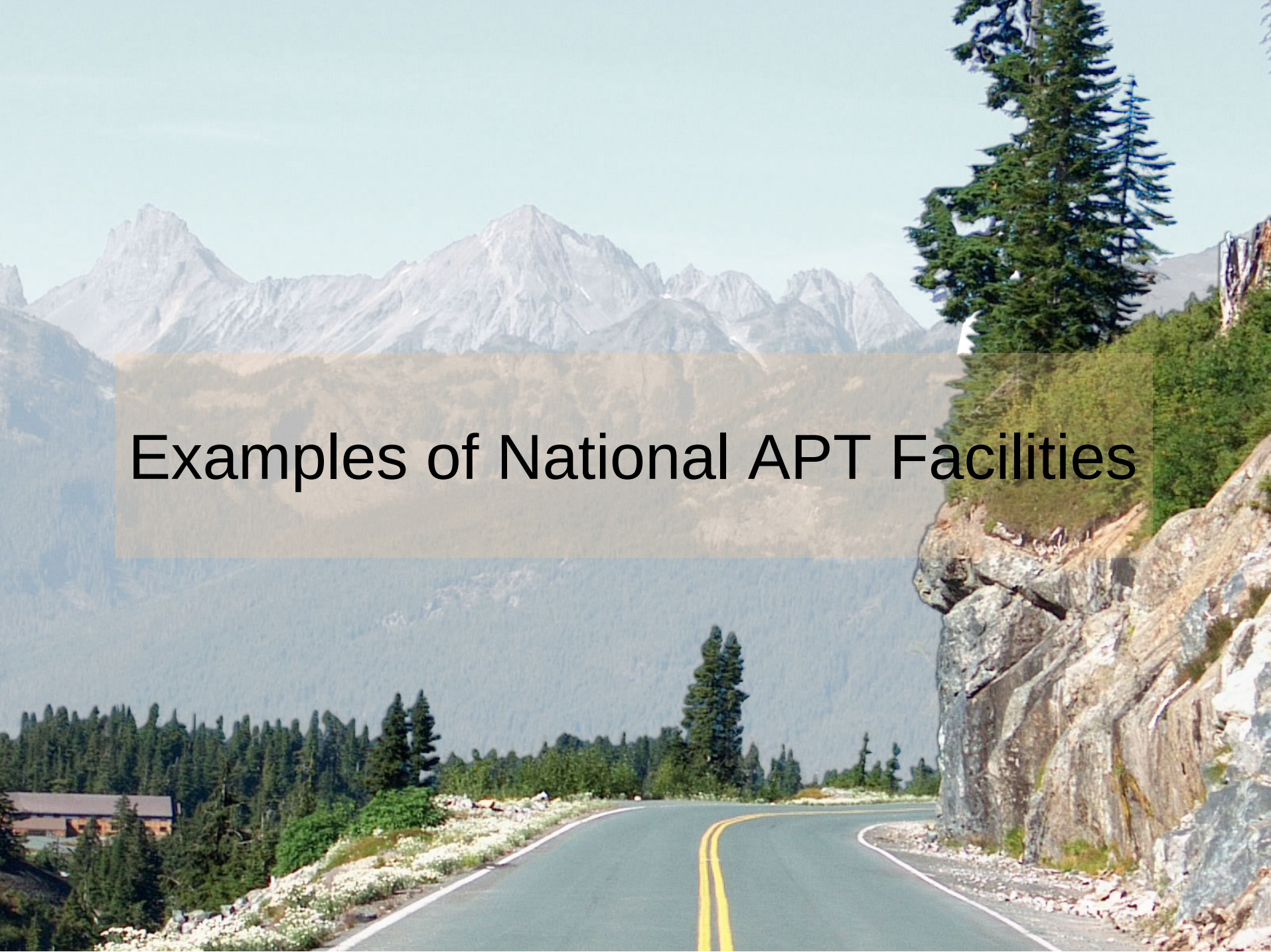
New Zealand CAPTIF

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

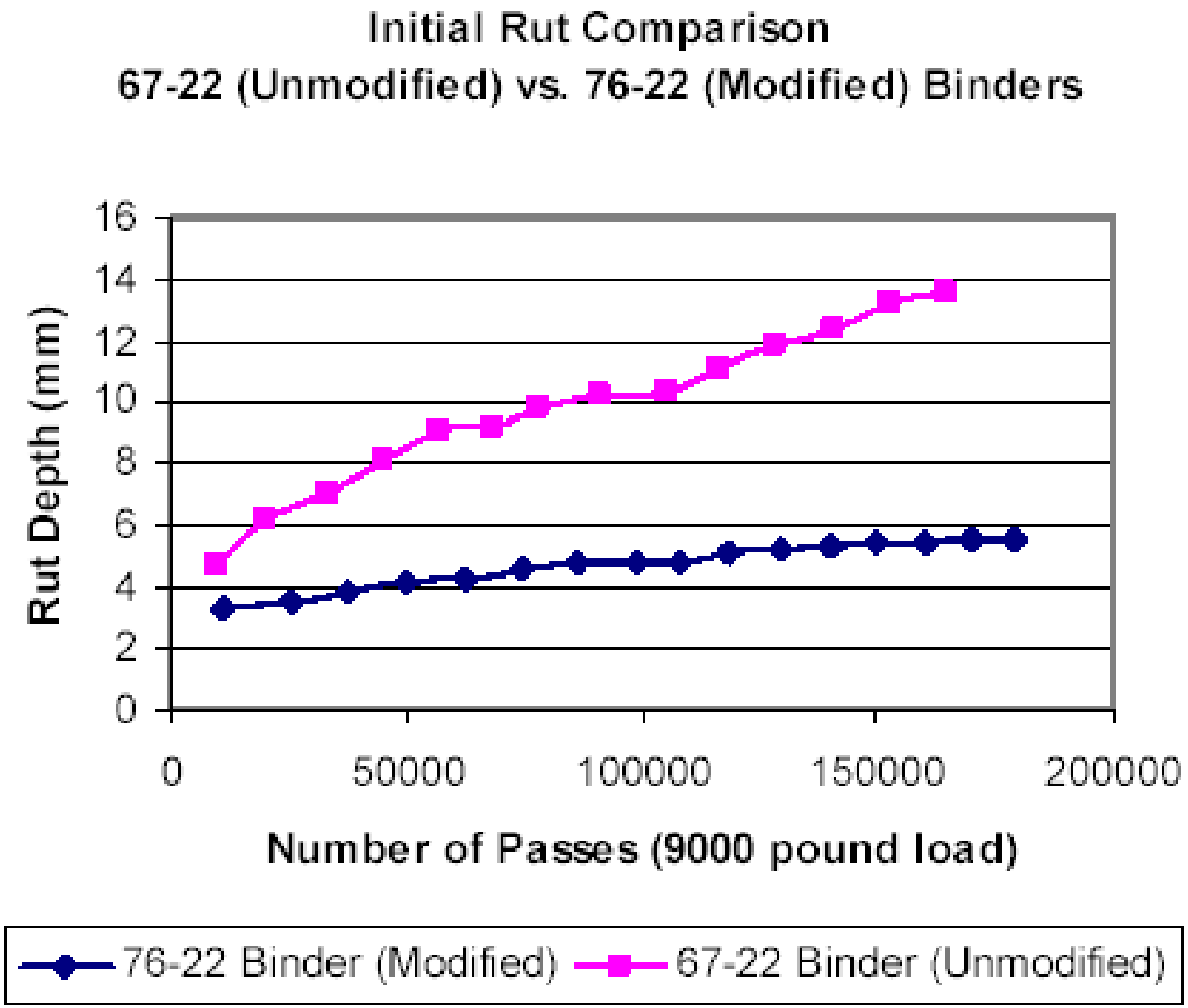
- Development of cracking models.
- Investigation of rubberized asphalt pavement performance.
- Investigation of inverted pavements using recycled asphalt pavement.
- APT is necessary in order to rapidly investigate materials and design.

Florida DOT

Accelerated Pavement Testing and Research Program

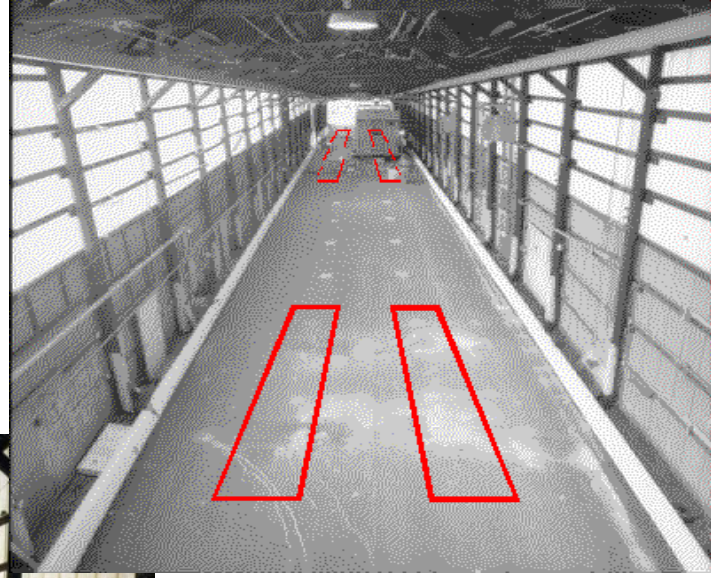
(Program started in 1999. First loads applied October 2000)

Florida DOT HVS Results



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

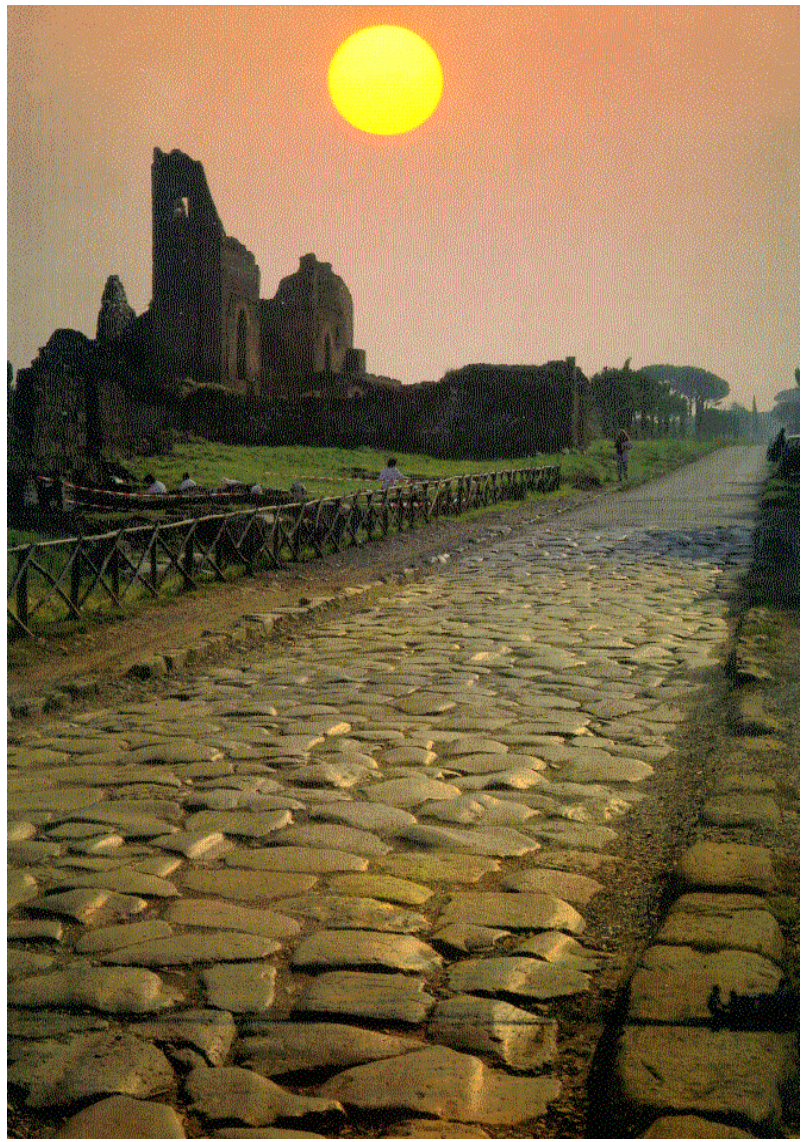
Summary

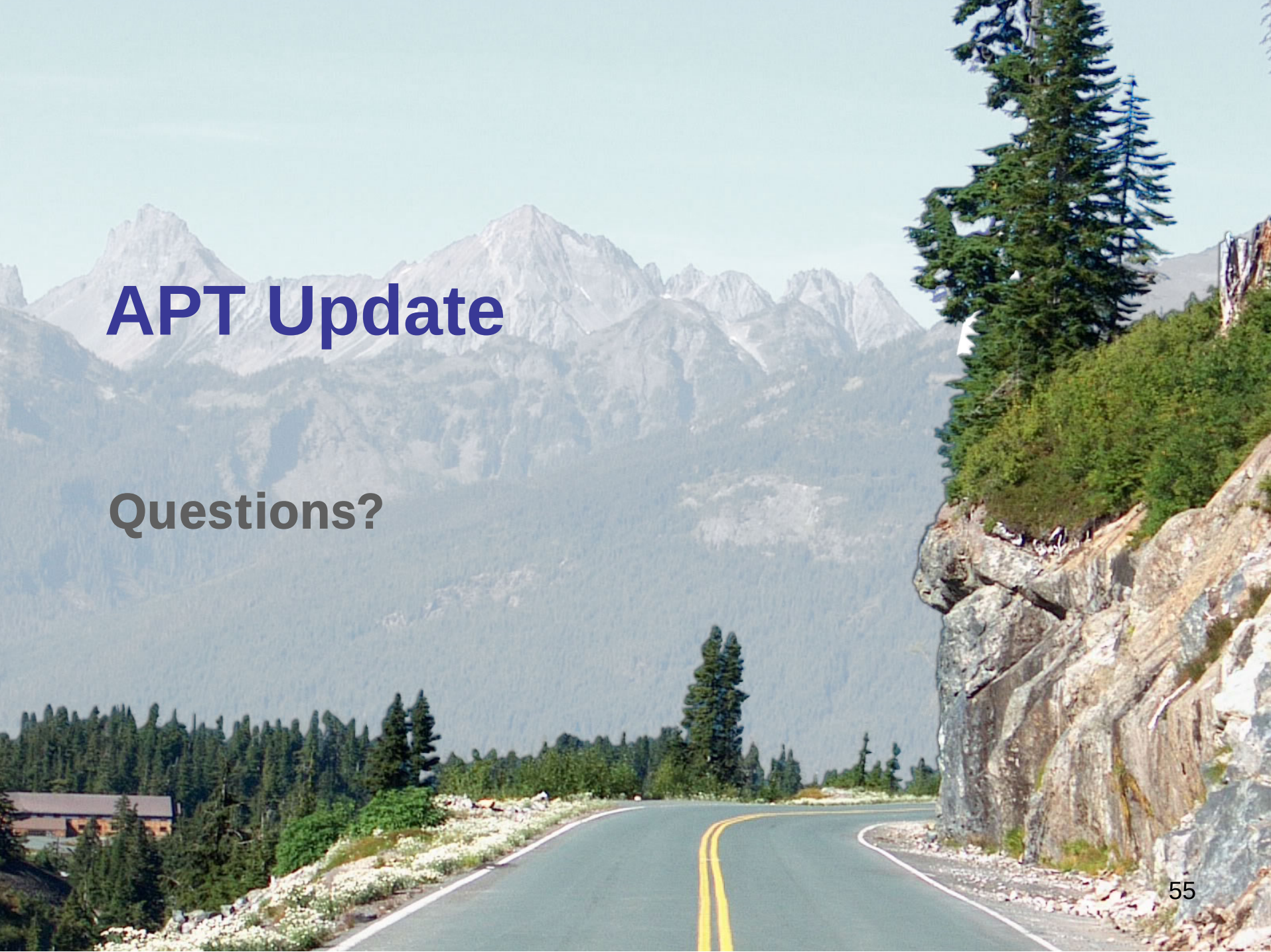
- APT programs have produced significant pavement findings over a period of at least 30 years.
- Outstanding APT countries and states
  - South Africa
  - France
  - Finland and Sweden
  - Spain
  - Australia
  - Florida
  - California
  - Minnesota
  - Alabama (NCAT)
  - Louisiana

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?