New asphalt pavements research, and long-life (perpetual) asphalt

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CalAPA
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Ontario, CA

UCPRC
UNIVERSITY of CALIFORNIA | PAVEMENT RESEARCH CENTER
Davis • Berkeley

2000 Vision for California Pavement Technology and 2015 Status

http://www.ucprc.ucdavis.edu/PDF/UCPRC-RR-2000-10.pdf

- Design Tool and Input Database
  - CalME being implemented as Caltrans standard asphalt new pavement and rehab design method
- Construction Productivity Tool and Database
  - CA4PRS implemented by Caltrans for corridor rehabilitation
  - Licensed by FHWA to all state DOTs
- Life Cycle Cost Analysis Tool and Input Database
  - FHWA's RealCost customized for California, used on all Caltrans rehabilitation projects

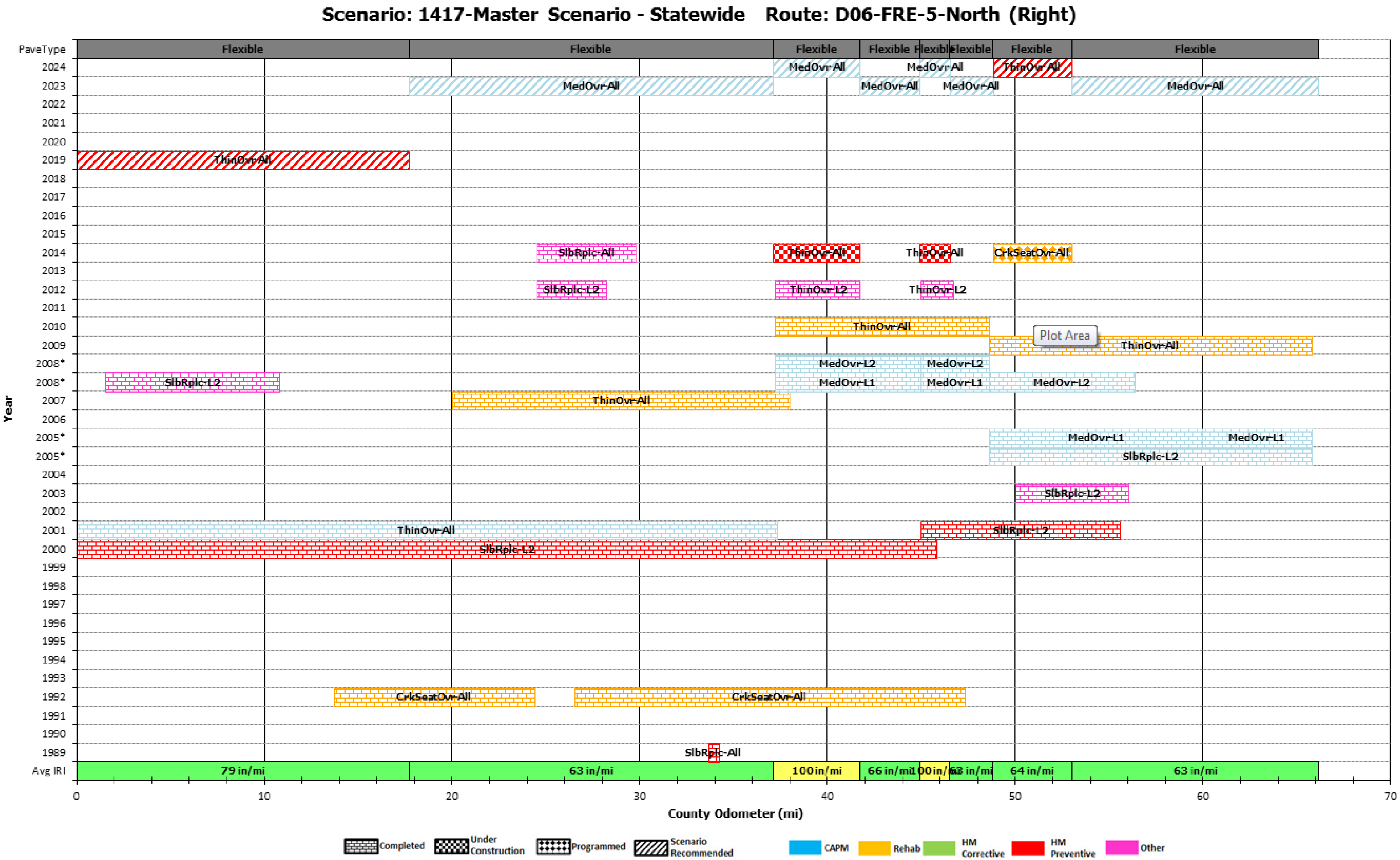
2000 Vision for California Pavement Technology and 2015 Status

- Specifications, Guidelines, Field and Lab Testing Tools
  - Long Life AC design and construction approach
  - CalBack back-calculation software for deflections
  - MB binder spec evaluation
  - PG binder implementation
  - WMA, RWMA evaluation process and implementation
  - Full-depth reclamation guidelines
  - Smoothness IRI specification, certification process
  - Performance related testing for asphalt

2000 Vision for California Pavement Technology and 2015 Status

- Pavement Management Tool and Databases
  - PaveM pavement management system developed and implemented
    - change from reactive to proactive maintenance and rehabilitation
    - 10 year look ahead of needs
  - Integrated Caltrans databases
  - Automated statewide pavement condition survey

PaveM example output screen: historical treatments and 10 year projected scenario for a 66 mil segment of I-5 in Fresno County



Expected goals for next 10 years

- Further development of mechanistic design
  - CalME for routine design
  - Improve and expand capability, improve user interface
  - Web based
  - Training, lab capacity in CT and industry
- Performance related testing and spec implementation
  - Driven by Superpave and need for performance related specs for binders and mix
  - Applicable to all current and future mix types
  - Tied to mechanistic design
  - Balanced for gain (information) versus pain (time, cost)
  - Use of multi-scale testing
    - Binder, fine aggregate mix and mix testing

Expected goals for next 10 years

- New “asphalt” materials
  - Faster innovation due to cost and availability of binders (asphalt and cement)
  - More recycled materials
    - More RAP (RAS?)
    - Rubberized RAP, RAP in rubber mixes
    - More forms and uses of recycled tire rubber
    - Methods and additives for “perpetual pavement recycling”
    - Asphalt/cementitious and other hybrid materials.
  - Performance evaluation for faster implementation through performance related specs (now we can test and analyze with CalME)

Expected goals for next 10 years

- Environmental and cost impact of designs, management and policies
  - Project level design
  - Network level management
  - Policies
    - Get the science ahead of the policies
    - Putting numbers to green marketing, indices
  - Joint consideration of agency cost, user cost and environmental impact

Current areas of UCPRC asphalt-related work for Caltrans, CalRecycle, CARB, FHWA and FAA
and some highlights on a few projects

Caltrans/UCPRC Pavement Research Road Map

http://www.dot.ca.gov/research/research_roadmaps/docs/Pavement_Research_Roadmap.pdf

FHWA Sustainable Pavement Task Group

http://www.fhwa.dot.gov/pavement/sustainability/

Pavement Research Roadmap (2014 - 2017)
Caltrans Division of Research, Innovation and Systems Information
UC Pavement Research Center

	CALTRANS PROGRAM AREAS						
	DESIGN, MATERIALS & CONSTRUCTION			ENVIRONMENTAL		MAINTENANCE	
PRIORITY TOPICS	**Mechanistic-Empirical Design**	**Performance Based Specifications**	**Construction Quality**	**Recycling**	**Sustainability**	**Preservation**	**Pavement Management**
STRATEGIC PROBLEMS	Reducing life cycle costs of pavements requires the ability to predict pavement performance more accurately than is possible with Caltrans' traditional design and analysis methods.	Current recipe-based specifications place most of the risk on Caltrans and don't allow for innovations.	Construction activities on near-capacity highways led to a need for shorter duration lane closures and high quality construction, which would reduce negative impacts on the public, goods movement, and the environment.	Decreasing availability of high quality material sources for pavement construction requires innovative methods of reusing or recycling sound, in-place materials.	Constructing and maintaining pavements have environmental impacts that must be assessed and reduced.	Pavement preservation techniques are not well understood within the transportation industry and state-of-the-art standards are nonexistent.	Data, on pavement infrastructure and performance, are not available to enable faster pavement improvements and innovations.
STRATEGIC OBJECTIVES	Develop and implement Mechanistic-Empirical (ME) methods, based on theories of mechanics, that can enable more accurate predictions leading to optimized pavement performance and lower life cycle costs.	Design and construct pavements with specifications that assure longer service lives and reduce congestion from recurring maintenance and rehabilitation work.	Provide methods and tools for faster construction (prefabrication, new techniques, new materials, composite pavements) in order to improve delivery of projects and services by Caltrans. Design and construct pavements with higher quality control and pavement characteristics that provide longer service lives.	Develop and promote high quality pavement recycling techniques for all kinds of pavement in order to preserve and enhance California's resources and investments.	Identify and quantify the environmental impacts of various construction and maintenance activities.	Use pavement preservation techniques and guidance to preserve and enhance California's resources and investments.	Develop a true Pavement Management System (PMS) to track pavement innovation, pavement structure and performance over time in order to preserve and enhance California's resources and investment.
RESEARCH APPROACH	After committing in 2005 to transitioning to ME, Caltrans has implemented a first version of ME design for concrete pavements. Further research is needed to enhance this tool. An ME design tool for asphalt pavements has been developed and is being implemented. Research includes developing new models and improving current ones, improvement of climate, materials and traffic databases, seasonal adjustments, sensitivity analyses, calibrating models with field data	Development of long life pavements requires innovative designs, materials, and construction followed by monitoring of pavement condition to evaluate short- and long-term performance. Identify the parameters that lead to long-term performance. Develop new performance based tests and specifications, including consideration of new materials and methods of quality assurance, using HVS validation where warranted before evaluation in pilot projects. Support transfer of capability to industry and the Department	Research various construction planning (e.g. imaging) and techniques (e.g. precast, improved materials) that will further enable reducing construction duration, impacts, cost, and traffic delay by streamlining pavement construction schedules, improving planning, and exploring new materials and specifications.	High quality pavement recycling will be improved over several years. Research will identify the most promising recycled materials through literature review and laboratory testing, evaluating techniques developed by other organizations and Caltrans' experience, using HVS validation where warranted before evaluation in pilot projects. Implementation will require validation of proposed changes and training Caltrans and contractor personnel.	Work with industry and other state agencies to identify and quantify environmental impacts (e.g. green-house gases, noxious gases, storm-water runoff, energy consumption, etc.) of construction and maintenance activities. Develop tools that will allow designers to assess the environmental impacts of various pavement work alternatives.	Pavement preservation research will quantify and correlate pavement circumstances (age, condition, climate zone and traffic load) to a suitable recommended course of preservation treatment. Research will include laboratory testing, analysis, and HVS tests where warranted. Best practice for treatment selection and timing for different conditions will be determined from current and future research.	A true PMS is being implemented by the Department. Continue to support improvements in collection and use of data. The database will continue to be modified to improve management of the network. Expansion of the database and adjustments to the PMS will be used to further improve performance models and treatment selection approaches, and calibrate ME design and analysis. Adjustments to Life Cycle Cost Analysis will be validated in case studies and integrated into decision processes for pavement management

DESIGN, MATERIALS & CONSTRUCTION

Mechanistic-Empirical Design

- **Standard Materials Library and Guidance (SPE3.30)**
  - Test and include additional regional materials and CIR, FDR in the Caltrans ME Standard Materials Library,
  - Implement procedures to simplify the selection of material types for ME design by district designers,
  - Develop guidance for asphalt mix designers to meet performance related mix design requirements
- **Improved ME Design and Reliability Approach (SPE 3.31)**
  - Improve the ability/reliability of Caltrans and national ME procedures to predict pavement distresses. Address upcoming changes in AASHTO test methods
- **Update project level asphalt surface design (SPE 3.36)**
  - Web based CalME

Performance Based Specifications

- **Performance-Related Specifications for Rubberized Asphalt Binder (SPE 4.50)**
  - Develop supporting data/information for the writing of performance related QC/QA specifications for mix design and mix placement of terminal blend and wet process asphalt rubber mixes.
- **Support for Superpave Implementation (SPE 3.32)**
  - Establish annual state-wide round robin for Hamburg Wheel Track Test (HWTT) study to determine precision and bias, and incorporate results in revised specifications.
  - Assess differences between laboratory and plant produced mix, and continued development and implementation of performance related tests.
  - Review appropriateness and applicability of QC/QA testing on Superpave projects and make recommendations for revised specifications if justified.
  - Monitor performance of Superpave projects constructed to date.
- **Simplified Performance Based Specifications for AC Long Life Projects (SPE 3.33)**
  - Complete the development of simplified asphalt mix design procedures and specification preparation for AC long life projects that are easier for contractors and districts to understand and communicate on, but do not increase the risk of poor performance to Caltrans.

ENVIRONMENTAL

Recycling

•Binder Replacement in High RAP/RAS Asphalt Mixes (SPE 4.51A&4.51B)

-Investigate binder replacement rates in high RAP/RAS mixes without the need for binder extraction. This is a phased study starting with binder testing and analyzing, followed by laboratory mix and field testing, and then APT if justified. The effects of asphalt modifiers (polymer and rubber), warm mix technologies, and rejuvenators will also be investigated.

•Improved Guidance and Specifications for Full-Depth Reclamation (SPE4.59)

-Develop integrated project selection and design guidelines and specifications for different full-depth reclamation (FDR) strategies. Assess performance of different FDR stabilization treatments under wet conditions using accelerated pavement testing on existing test sections. Continue field monitoring.

Sustainability

•Validation of Greenhouse Gas Emissions from Pavement Deflection (SPE 4.53)

-Finalize evaluation of mechanistic equations from MIT and other research centers for energy dissipation from vehicle operation. Analyze with full year simulations for climates/structures/traffic.

-Perform field validation of fuel economy differences, compare field results with calculated results, and then perform comprehensive assessment.

•Environmental Life Cycle Assessment Updates and Applications (SPE 4.54)

-Develop additional/improved methods for LCA for the range of design, construction, maintenance, and rehabilitation strategies used in California following the Pavement LCA Roadmap.

•Updated Greenhouse Gas Emission Evaluations (SPE 4.55)

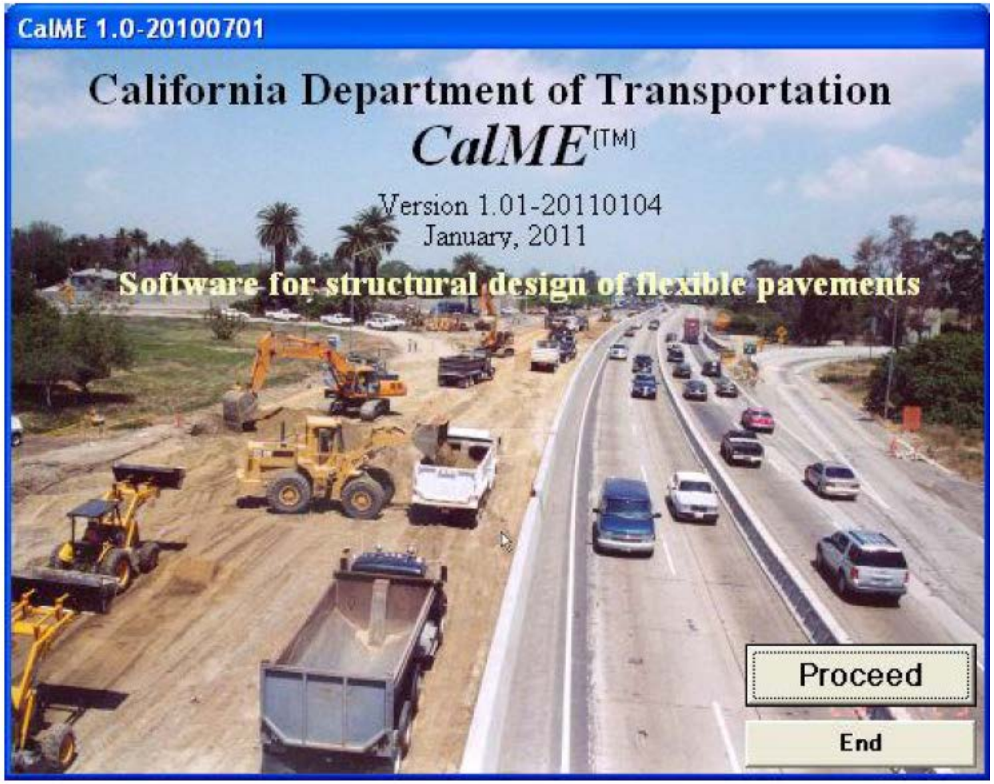
-Update Greenhouse Gas Emission methodologies for pavement management based on validation and calibration of LCA methods for pavement effects on vehicle emissions. Provide recommendations for improved simplified LCA GHG evaluations.

MAINTENANCE

Preservation	Pavement Management
•Effects of Pavement Roughness on Freight Movement (SPE 4.56) -Assess effects of roughness on cost of freight transport, choice of routes by haulers, and on emissions. Additional types of freight, districts, and routes will be assessed. **•Guidelines for Preservation Treatments for Bicycle Routes (SPE 4.57)** -Use results of recent cyclist comfort study for chip seal textures to test more Caltrans treatments for texture, and prepare guidelines for selection of preservation treatments that can be used on bicycle routes on state highways. .	**•Evaluate Traffic Speed Deflection Measurement (SPE 4.60)** **•Improved Smoothness and Distress Models and Benefits Equations for PaveM (SPE 5.01)** **•Performance Models for Seal Coats in PaveM (SPE 5.02)** **•Evaluate Composite Pavement Performance and Decision Trees (SPE 5.03)** **•Algorithms for Grouping Segments into Projects in PaveM (SPE 5.04)** **•New Life Cycle Cost Optimization Models for PaveM (SPE 5.05)** **•Evaluate APCS Data Collection and PaveM Engineering Configuration (SPE 5.06)** **•Evaluate Linear Reference System (SPE 5.07)** **•Document PaveM Traffic Updating Processes (SPE 5.08)** **•Update PaveM Engineering Configuration and Graphical User Interface (SPE 5.09)** **•Update Guidance and Calculations for Life Cycle Cost Analysis(SPE 5.10)**

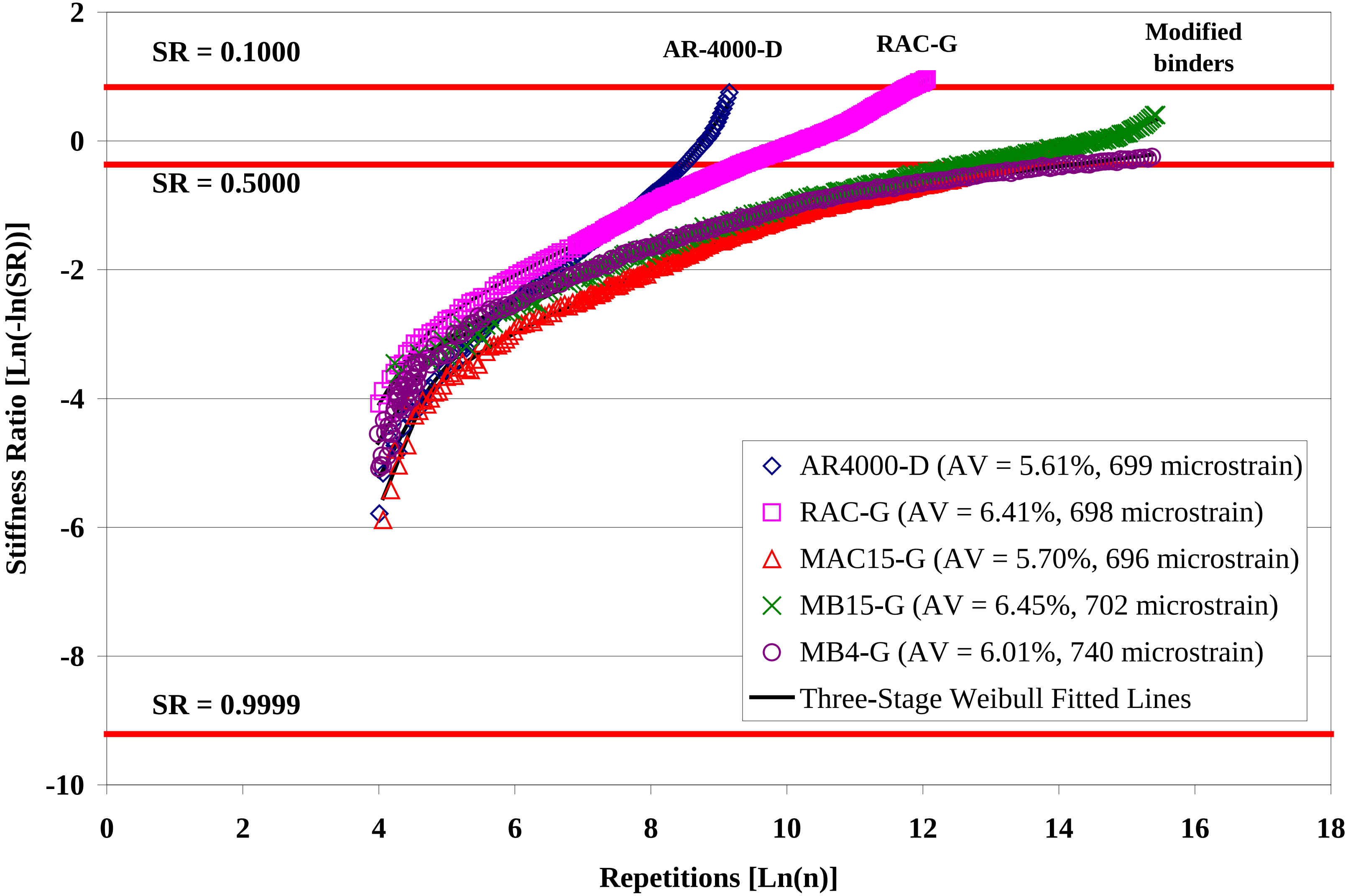
CalME Overview

- Introduced in 2006
- Focus on rehabilitation and preservation
- Incremental – Recursive approach
  - Simulation and updating of damage through life
  - Simulation of new pavement, rehabilitation and subsequent pavement preservation treatments
  - Standard materials library of performance related test results
  - Caltrans to be rolling out in next two years to districts



Asphalt Fatigue Damage in CalME

- Considers entire damage process



2014-17 Developments for CalME

- Expand materials database with each new project
  - High RAP mixes
  - Different rubber mixes
  - CIR and FDR
- New models being developed:
  - Full-depth reclamation
    - Cement stabilized
    - Engineered emulsion stabilized
  - Fabric and other interlayers
  - Additional cemented bases
  - Improved aging models
  - Thixotropy (rest periods)
  - Improved temperature modeling and consideration of sources of water
- Coding web based version

Focus of 2014-17 plant mix recycling work

- Properties of combined virgin and asphalt binder
  - Amount of binder blending for different time and temperatures paths
  - Aging characteristics of high RAP mixes
  - Fatigue properties
    - Binders
    - Fine aggregate mixtures (FAM)
    - Mix testing
- Rubberized RAP
- RAP in rubberized
- RAP in airfield mixes (FAA)

Focus of 2014-17 in-place recycling work

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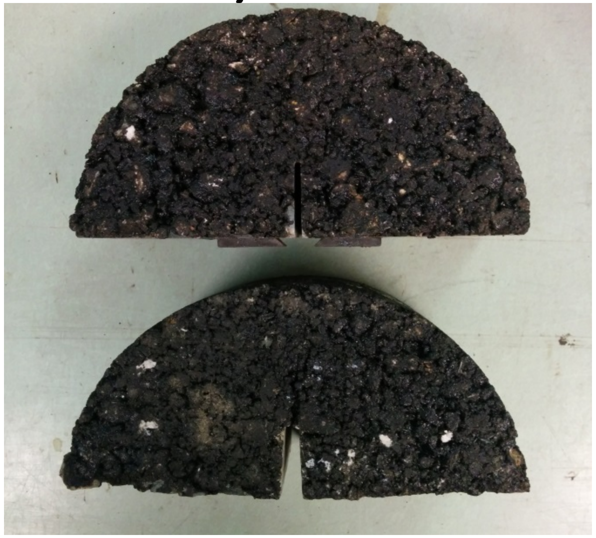
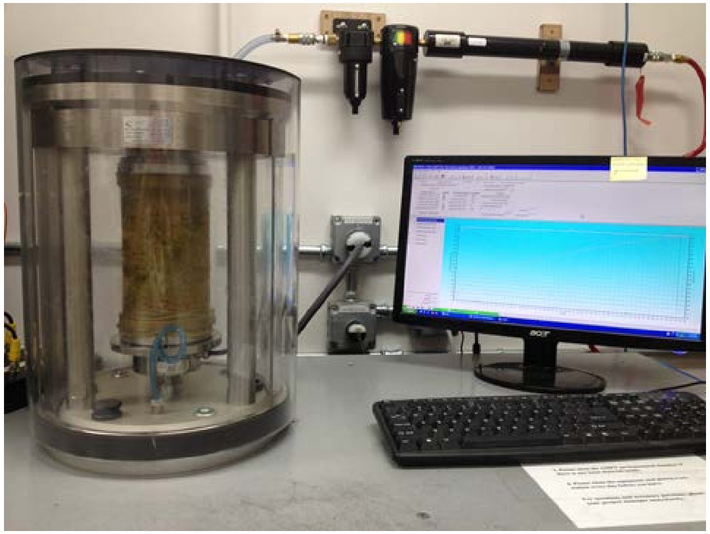
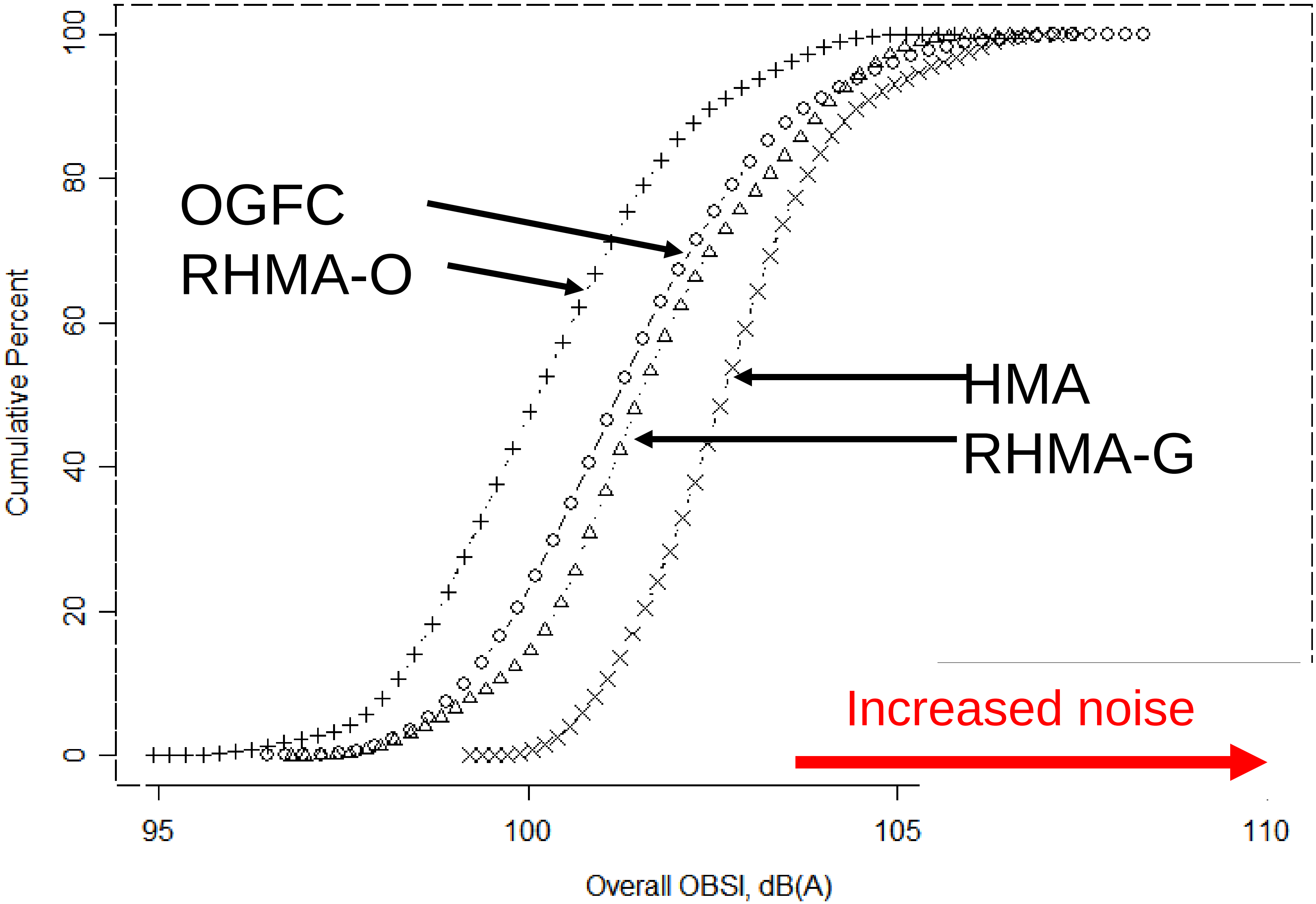
Superpave implementation support preliminary recent results (under CT review)



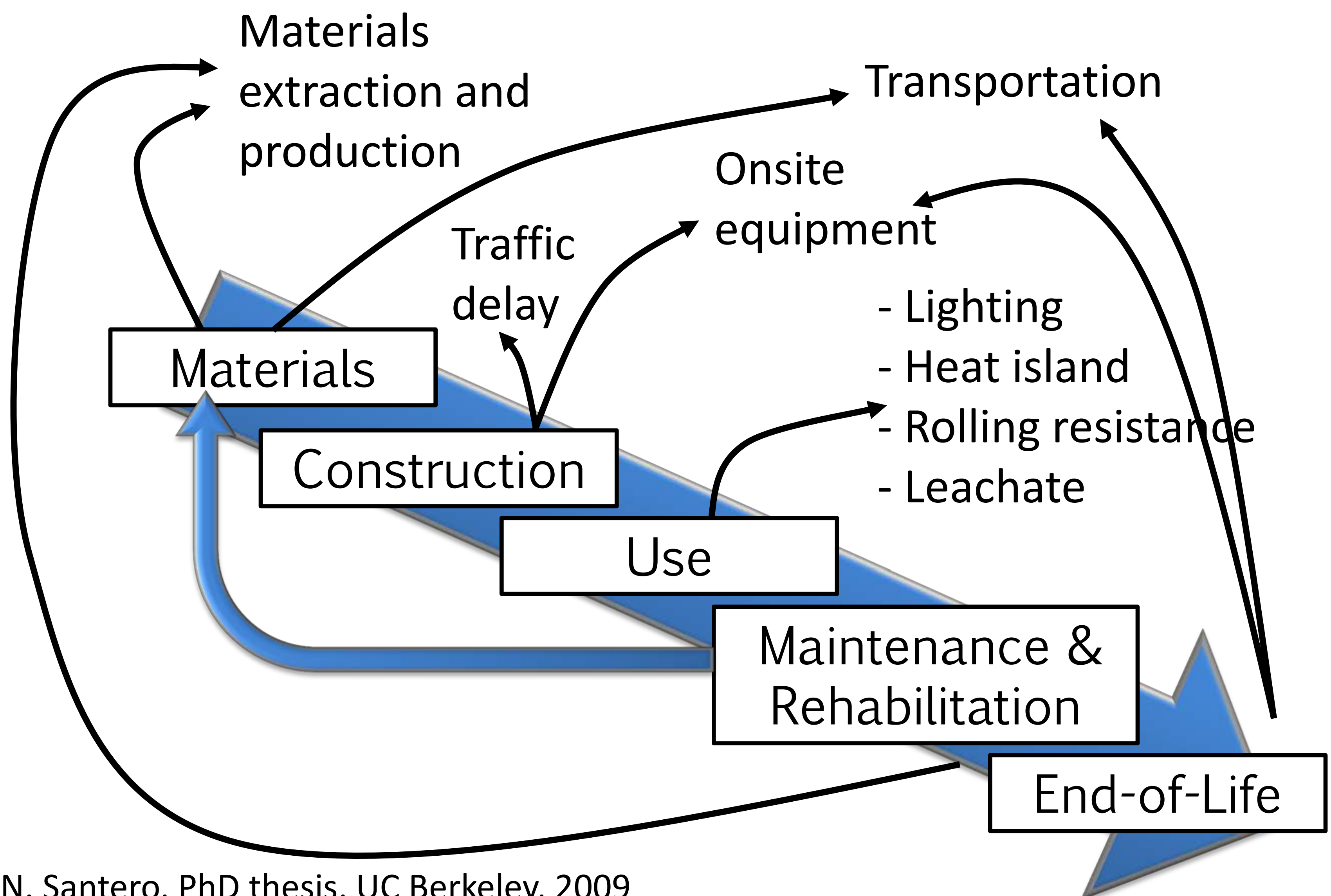
- CalME Evaluation of performance Hveem v. Superpave mixes
  - SP rutting performance worse,
    - but risk level still acceptable
  - SP cracking performance better,
    - can design thinner pavements
- Performance related tests, current recommendation
  - Repeated load triaxial (RLT) unconfined for rut
  - Four point beam for fatigue, investigate Semi-circular beam for fast mix design and QC/QA testing
    - (NCHRP 9-57 Texas A&M)
  - HWTT for moisture



OBSI noise with SRTT tire at 60 mph
Performance over 15 years: Use RHMA-O



The Pavement Life Cycle

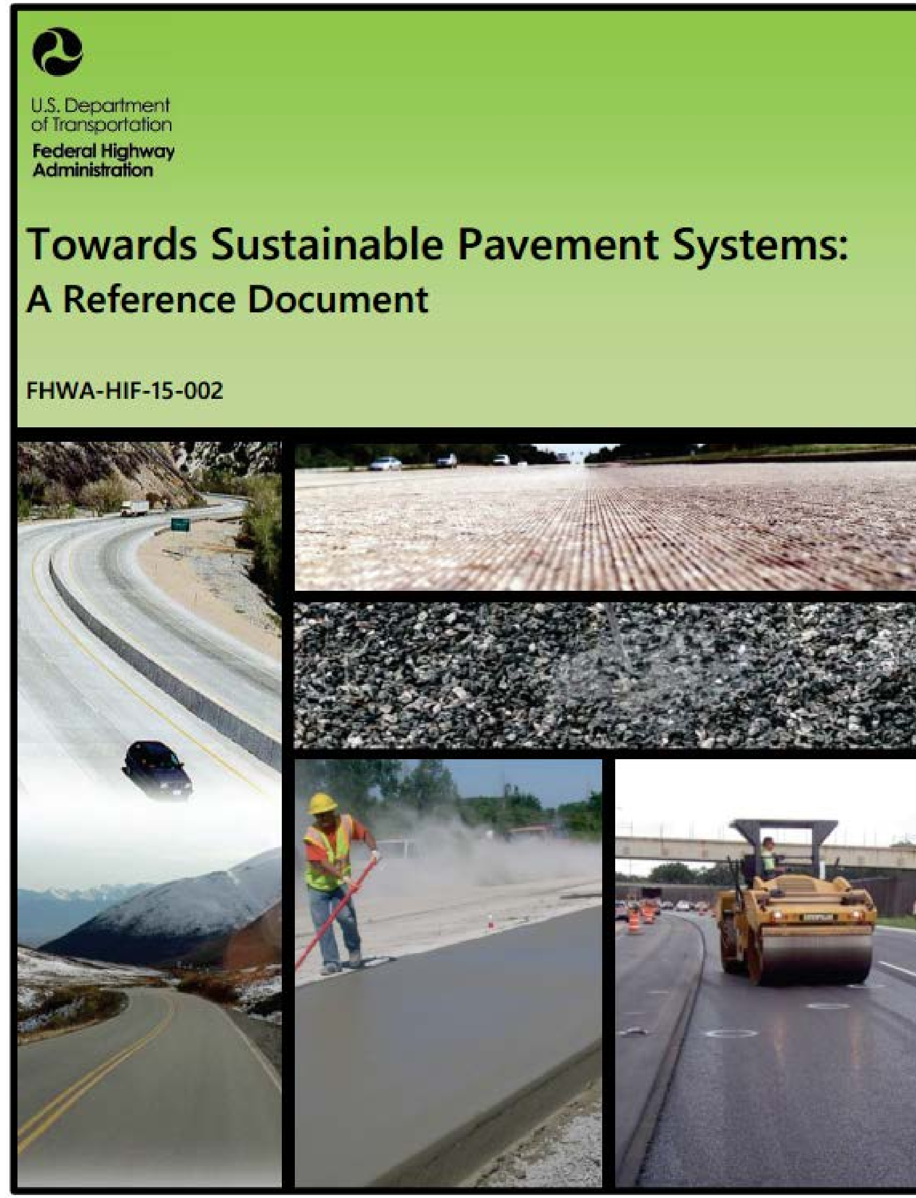


N. Santero, PhD thesis, UC Berkeley, 2009

FHWA Sustainable Pavements Task Group

- FHWA
  - Reference document February 2015
    - Covers all pavement life cycle phases
  - LCA guidelines by Sept 2015
  - Tech briefs and webinars

http://www.fhwa.dot.gov/pavement/sustainability/ref_doc.cfm



Environmental Product Declaration (EPD): Concise, quantitative information

NAPA, Asphalt Institute currently developing rules for producing this type of information; NRMCA already doing it

Image source: adapted from N. Santero
Pavement Interactive

Environmental Facts

Functional unit: 1 metric ton of asphalt concrete

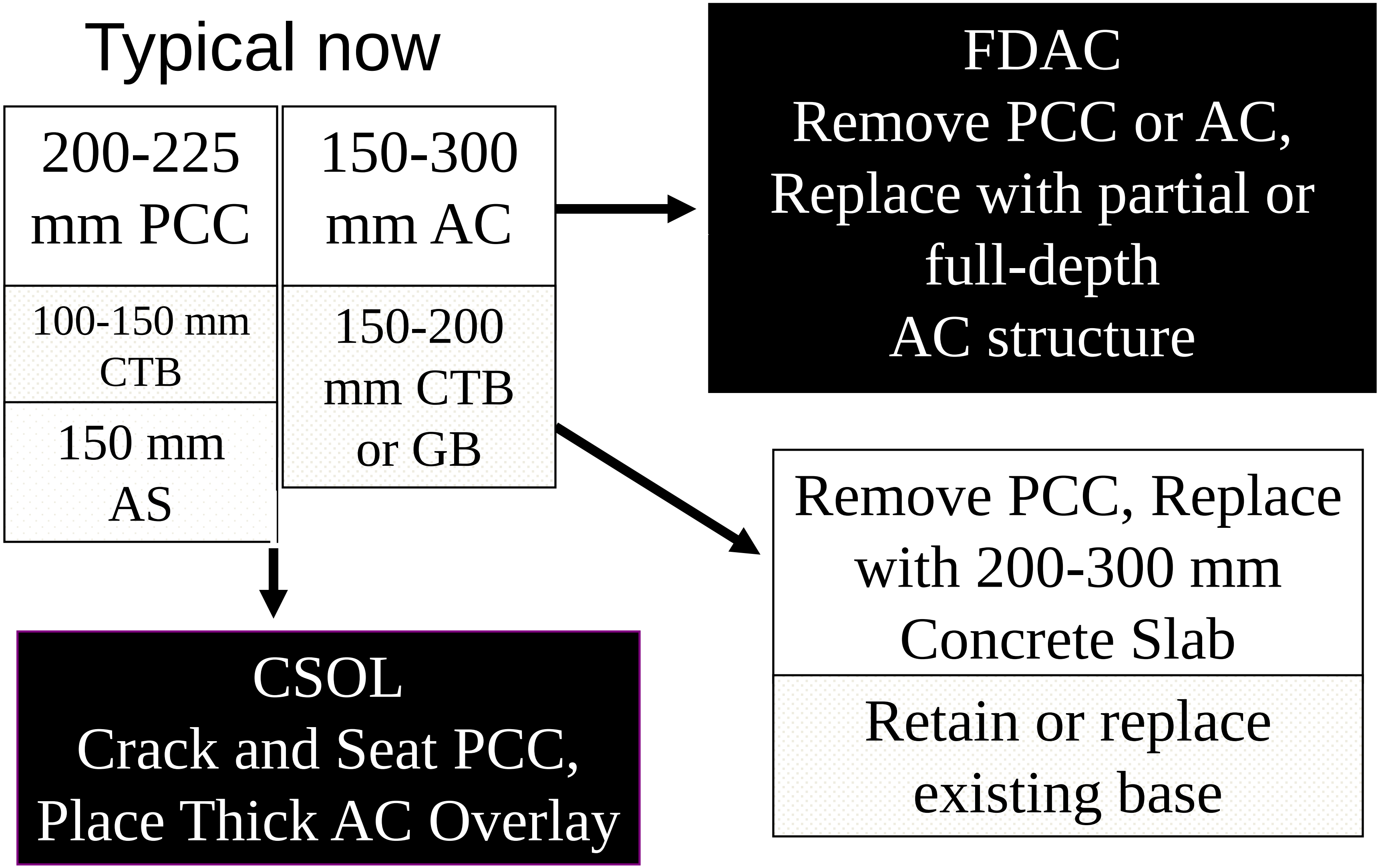
Primary Energy Demand [MJ]	4.0×10^{3}
Non-renewable [MJ]	*3.9×10^{3}*
Renewable [MJ]	*3.5×10^{2}*
Global Warming Potential [kg CO_2-eq]	79
Acidification Potential [kg SO_2-eq]	0.23
Eutrophication Potential [kg N-eq]	0.012
Ozone Depletion Potential [kg CFC-11-eq]	7.3×10^{-9}
Smog Potential [kg O_3-eq]	4.4

Boundaries: Cradle-to-Gate
Company: XYZ Asphalt
RAP: 10%

Example LCA results

www.ucprc.ucdavis.edu/LCA2014

Current Long-Life Rehabilitation Strategies



Long Life AC: California Practice

- General Principles
  - Right material in the right place in the structure
  - Thinner pavement = faster construction
  - Materials properties specified for performance related tests
  - Design to drive distresses to occur at the surface, not in the underlying layers
  - Consider within-project variability in reliability calculations
- Caltrans Design Criteria
  - 40 year structural design life for rutting, fatigue cracking
  - 95% reliability
  - 15 year design life for sacrificial layer (RHMA-O)

Crack, Seat and Overlay

Sacrificial layer – safety, noise — 25-50 mm

Top layer – rutting, cracking — 50-100 mm

Middle layer – cracking, rutting, high RAP — Varying thickness

fabric

Bottom layer - cracking — 30 mm

Existing grade

Cracked and Seated PCC

Base layers

subgrade

Full-Depth Asphalt Concrete

Existing grade	
Sacrificial layer – safety, noise	25-50 mm
Top layer – rutting, cracking	50-100 mm
Middle layer – cracking, rutting high RAP	Varying thickness
Rich Bottom layer - cracking	50-75 mm
granular base (recycled PCC, CTB, granular)	0 or 150 mm
subgrade	

Reduce Thickness to Speed Full-Depth Construction Under Bridges

Traditional materials
and ME design

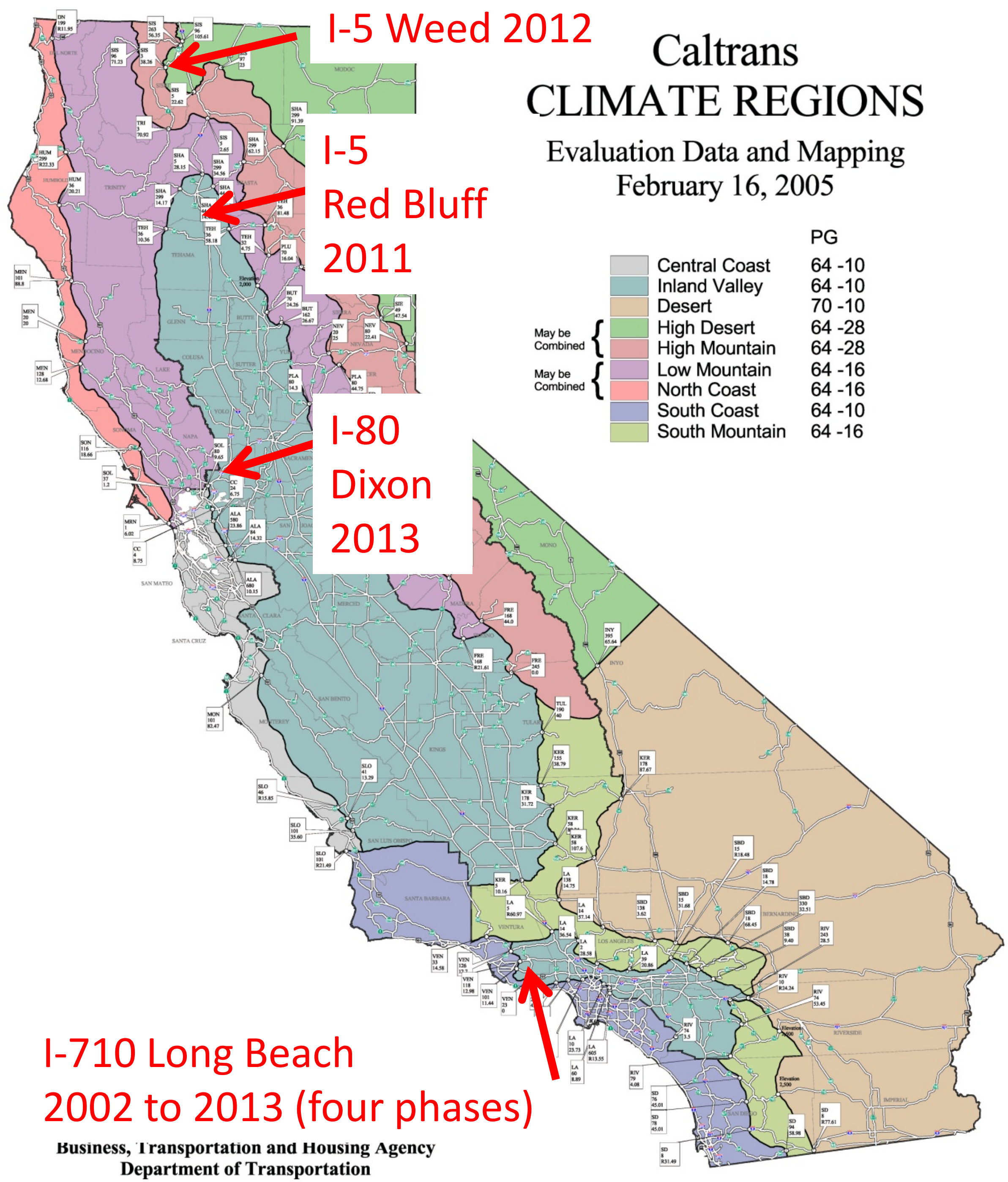
535 mm thick (21 in.)

8 % air-voids
same mix design throughout
AR-4000 std binder

ME design using
- Improved compaction
- Stiffer binder
- Rich Bottom

300 mm thick (12 in.)

75 mm polymer 5% air-voids
150 mm AR-8000
5% air-voids
75 mm AR-8000, 2% air-voids
+0.5% binder



Long Life AC Projects to Date

- 2011/13 projects also pilots for inclusion of 25% RAP

Sum and Future directions for AC Long Life

- Specifications and designs appear to be working; good performance on I-710 (12 years)
- Things to change based on lessons learned:
  - Make mix design process schedule faster
  - Change testing procedures to reduce time
  - Simplified tests for QC/QA
  - Provide guidance to contractors on how to change mixes to meet performance related rutting, fatigue and stiffness requirements

Questions?

Reports and info at

www.ucprc.ucdavis.edu

10 WEEKEND CLOSURES
(Subject to change)

Weekend 1:	Friday - Mon.	Aug. 5 - 8
Weekend 2:	Friday - Mon.	Aug. 12 - 15
Weekend 3:	Friday - Mon.	Aug. 19 - 22
Weekend 4:	Friday - Mon.	Aug. 26 - 29
Weekend 5:	Friday - Mon.	Sept. 9 - 12
Weekend 6:	Friday - Mon.	Sept. 16 - 19
Weekend 7:	Friday - Mon.	Sept. 23 - 26
Weekend 8:	Friday - Mon.	Sept. 30 - Oct. 3
Weekend 9:	Friday - Mon.	Oct. 7 - 10
Weekend 10:	Friday - Mon.	Oct. 14 - 17