Pavement Research Roadmap (2011 - 2014)
Caltrans Division of Research & Innovation and UC Pavement Research Center

Roadmap for Pavement Research

Vision *Pavement research improves mobility across California by finding ways to deliver pavement projects more efficiently, preserving pavement assets through longer service life, reducing environmental impact through smoother pavements and reduced maintenance, and providing the safest transportation system in the nation.*

Mission Provide implementable research results enabling new and innovative business practices that span the Department's functional program areas through enhanced designs, materials, specifications, methods, tests, equipment, manuals, policies, and procedures.

	CALTRANS PROGRAM AREAS							
	DESIGN, MATERIALS & ENVIRONMENTAL				CONSTRUCTION		MAINTENANCE	
PRIORITY TOPICS	**Mechanistic-Empirical Design**	**Improving Pavement Performance**	**Recycling and Sustainability**	**Quiet Pavement**	**Construction Practices and Project Delivery**	**Smoothness**	**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.	Congestion, increased travel times, and accidents associated with frequent construction and maintenance activities have become more prevalent with increases in population.	Decreasing availability of high quality material sources for pavement construction requires innovative methods of reusing or recycling sound, in-place materials.	Public perception is that noise levels from vehicle tire/pavement sources is unacceptable and could be made quieter for a better quality of life.	Construction activities on near-capacity highways led to a need for shorter duration lane closures and higher efficiency of construction, which would reduce negative impacts on the public, goods movement, and the environment.	Perception by the public is that pavements as currently constructed and maintained within California often provides an unacceptably poor ride quality.	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 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 higher quality control and pavement characteristics that provide longer service lives and reduce congestion from recurring maintenance and rehabilitation work.	Develop and promote high quality pavement recycling techniques (both hot and/or cold) in order to preserve and enhance California's resources and investments.	Construct and maintain quieter pavements in order to preserve and enhance California's resources and investments.	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.	Construct and maintain smoother pavements in order to optimize transportation throughput and provide dependable travel times as well as providing the safest transportation system in the nation for users and workers.	Use pavement preservation techniques and guidance, including development of a center of excellence for training and research in order 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 and to develop and implement an ME design tool for asphalt pavements. Research includes developing models, climate and materials databases, seasonal adjustments, sensitivity analyses, calibrating models with field data, developing simple design tools, and assisting with implementation.	Development of long life pavements requires innovative designs, materials, and construction followed by monitoring of pavement condition to evaluate short- and long-term performance. Results from monitoring provide validation and further calibration data to realize cost-efficient, long-life designs of major urban corridors. Projects also provide data to help implement ME and validate innovative construction practices.	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 (both hot and cold) developed by other organizations and Caltrans' experience, then followed by HVS validation before evaluation in pilot projects. Implementation will require validation of proposed changes and training Caltrans and contractor personnel.	Research over the next several years will develop new design, construction, and maintenance approaches to quiet pavements. FHWA's 2005 policy requires multiple years of monitoring "quieter pavements". Laboratory testing and development of new asphalt surface mixes aim to optimize pavement ride quality, noise, pavement permeability and durability properties. Future implementation of new mix designs will follow field testing, calibration and validation.	Development of tools that analyze construction, e.g. CA4PRS software, now make it possible to determine optimal construction work schedules in a fraction of the time than traditional methods. Research will further enable reducing construction duration, impacts, cost, and traffic delay by streamlining pavement construction schedules, improving planning, and exploring new materials and specifications.	New equipment for measuring smoothness will be evaluated and may have to be procured. Specifications and procedures will be studied and developed. Resources to maintain, calibrate, and use new equipment will be required. Construction pay factors may require adjustments. This topic is supported by research on Quiet Pavements and Composite Pavement Systems (*Strategic Highway Research Program*, project SHRP R-21).	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. Best practice for treatment selection and timing for different conditions will be determined from current and future research.	A true PMS will require changes in equipment, data collection, analysis (amount, capabilities, & automation), particularly for as-built and condition survey 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 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.

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PROJECT TITLES and descriptions	• **Coefficient of Thermal Expansion in PCC Pavement Design and Specification (SPE 4.30, TID 2310)** - Assess the significance of CTE on early and longer-term cracking performance to determine how CTE should be considered in design and materials specifications for use in PCC pavements in California. • **Early-Age Cracking Performance (SPE 4.32, TID 2352)** - Identify potential causes and develop appropriate design parameters and/or construction procedures to limit or prevent early age cracking in PCC pavements. • **Differences in Fatigue Performance of Mixes with Same PG Binder Grade (SPE 4.33, TID 2355)** - Quantify the effects of the binder source on fatigue performance of Caltrans mixes and develop guidelines to take into account binder source effects on HMA mix design in Caltrans HMA specifications and designs. • **Updated Standard Materials Library (SPE 3.18, TID 2356)** - Update the state asphalt materials library with new materials (e.g. cold-foam, cement stabilization, RHMA, etc.) • **Interlayer Performance (SPE 4.34, TID 2359)** - Develop interlayer performance models and interlayer use guidelines.	• **Life-Cycle Cost and Environmental Life-Cycle Analysis for Composite Pavements (SPE 3.20, TID 2371)** - Incorporate the life-cycle cost and environmental life-cycle assessment of composite pavements into Caltrans documents.	• **Use of Higher Quantities of RAP and RAP Warm-Mix Interactions (SPE 4.35, TID 2373)** - Develop guidelines and recommendations for using increased RAP quantities in Caltrans mix designs. • **Recycling of RHMA in RAP and Full-Depth Reclamation Projects for both Hot and Warm Mix Technologies (SPE 4.36, TID 2374)** - Develop guidelines and recommendations for using RHMA in RAP and recycling it into new pavement layers in full-depth (FDR) and partial-depth reclamation (PDR) projects. The guidelines will include hot and warm mix technologies. • **Use Environmental Life Cycle Assessment to Develop Simplified Tools and Recommend Practices to Reduce Environmental Impact of Pavements (SPE 4.37, TID 2376)** - Identify network and project-specific practices for pavement design, materials selection, traffic handling, and maintenance and rehabilitation practices that will reduce environmental impact and use of finite resources. Develop approach to consider agency costs with environmental impact, through development of a multi-criteria decision making process.	• **Implementation of New Quieter Pavement Research (SPE 3.21, TID 2380)** - Develop specifications, guidelines, standardized laboratory and field test methods and other information needed to incorporate quieter pavement research into standard Caltrans practice. • **Acoustical Longevity of Noise Reducing Pavement (SPE 4.38, TID 2377)** - Develop models for pavement acoustics for use in the PMS, LCCA, and by district and HQ managers and engineers. • **Continued Monitoring of Selected Quieter Pavement Test Sections (SPE 4.39, TID 2375)** - Complete data sets to failure for concrete and asphalt quieter pavement and experimental test sections that remain in service. Data will be used in the proposed project "Acoustical Longevity of Noise Reducing Pavement".	• **Effects of WMA Technologies on Binder Aging (SPE 4.40, TID 2370)** - Develop revised HMA, RHMA-G and RHMA-O performance models that take the effects of different binder aging behavior related to the use of warm-mix asphalt into consideration. • **Environmental Impacts and Energy Efficiency of Warm Mix Asphalt (SPE 4.41, TID 2366)** - Quantified environmental benefits of using warm-mix asphalt technologies. • **Evaluation of Compacted HMA Moisture Sensitivity (SPE 3.23, TID 2365)** - Develop data relating laboratory mix moisture sensitivity to field performance. Prepare revised guidelines, test methods, limits, and specifications for moisture sensitivity testing.	• **Certification of Inertial Profilers used in PMS and Construction Monitoring (SPE 3.24, TID 2364)** - Develop a certification procedure and establish a facility for certifying/calibrating inertial profilers in California. • **Effects of Milling and Other Repairs on Smoothness of Thin Overlays (SPE 4.42, TID 2363)** - Develop guidelines and revised specifications for pre-overlay treatments and smoothness for thin overlays.	• **Improved Methodology for Mix Design of Open-Graded Friction Courses (SPE 3.25, TID 2362)** - Develop guidelines, revised test procedures, and revised specifications for mix design of open-graded friction courses.	• **Performance Modeling (SPE (4.43, TID 2358)** - Develop new and refine existing performance prediction models for California. Develop initial estimates of future condition using models. • **Update Life-Cycle Cost Analysis Manual with New Performance Data (SPE 3.27, TID 2357)** - Prepare updated default data for Caltrans LCCA manual. • **Complete QA on Automated Pavement Condition Survey and GPR contracts (SPE 3.28, TID 2354)** - Quality assurance on the automated pavement condition survey and GPR contracts.

For information on past research projects, visit (Caltrans) http://www.dot.ca.gov/research/researchreports/index.htm and (PPRC) http://www.ucprc.ucdavis.edu
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PROJECT UPDATES Quarter 3 1/31/12 to 3/31/12	• **Coefficient of Thermal Expansion in PCC Pavement Design and Specification (SPE 4.30, TID 2310)** - No progress this period • **Early-Age Cracking Performance (SPE 4.32, TID 2352)** - No progress this period • **Differences in Fatigue Performance of Mixes with Same PG Binder Grade (SPE 4.33, TID 2355)** - Progress on the workplan for this study continues. Initial discussion were held with Caltrans regarding materials to be included. Studies into related research on fatigue performance has continued and will continue throughout this project. No laboratory testing was performed this quarter. A large amount of aggregate sieved. • **Updated Standard Materials Library (SPE 3.18, TID 2356)** - Aggregates for the first mix in the experiment plan have been prepared for HMA specimen production. The second aggregate has been sourced. A questionnaire has been sent to DMEs regarding which mixes are most suitable for testing in this research. - UCPRC working with RE, DME, & contractor to evaluate field mix performance with shear tests. J. Signore presented ME design principles to RE, DME, & contractor in Redding. J. Signore attended pre-construction meetings and is in discussions with contractor's representative regarding lab testing. Completed ME training material and delivered to Caltrans. - Four mixes have been evaluated for optimum binder content (OBC). Additional materials have been sourced. Work continues on mix and material preparation for additional testing.	• **Life-Cycle Cost and Environmental Life-Cycle Analysis for Composite Pavements (SPE 3.20, TID 2371)** - No progress this period	• **Use of Higher Quantities of RAP and RAP Warm-Mix Interactions (SPE 4.35, TID 2373)** - Continued literature and FHWA/NAPA RAP/RAS expert task group/technical working group reviews to determine state of the practice and identify specific research needs. Started identification of long-term monitoring sites. Started test track design. Completed workplan for project. • **Recycling of RHMA in RAP and Full-Depth Reclamation Projects for both Hot and Warm Mix Technologies (SPE 4.36, TID 2374)** - Continued literature review and industry meetings to determine state of the practice and new development, and to identify specific research needs in full and partial depth recycling. Started identification of field test sites. Completed workplan for project. Started test track design and mix design investigations. • **Use Environmental Life Cycle Assessment to Develop Simplified Tools and Recommend Practices to Reduce Environmental Impact of Pavements (SPE 4.37, TID 2376)** - Outline of work plan completed. Models updated with new information from ACPA and PCA, use phase models refined with better information. Completed simplified equations and memo, reviewed with Caltrans, sent to Agile Assets for inclusion in PaveM. Completed revisions to concrete case studies, made some small changes in each phase data based on reviews.	• **Implementation of New Quieter Pavement Research (SPE 3.21, TID 2380)** - Completed Sac 5 – PM 20/21.5 evaluation, completed Sac 5 – PM 1.5/3.0 evaluation, and initiated evaluation of Sac 80 – PM 13/14.0. - This period was spent completing half of the rutting HVS tests, and all moisture HVS tests. • **Acoustical Longevity of Noise Reducing Pavement (SPE 4.38, TID 2377)** - Received draft work plan from Danish Road Institute. Met and discussed data sources and approach. • **Continued Monitoring of Selected Quieter Pavement Test Sections (SPE 4.39, TID 2375)** - Cold temperature data was collected for the temperature effects study. - The revised list of quieter pavement test sections was submitted to Caltrans and approved. - Laboratory testing of open-graded materials from Arizona test sections nearly completed (most work on this task performed in previous contract).	• **Effects of WMA Technologies on Binder Aging (SPE 4.40, TID 2370)** - Continued literature review to determine state of the practice and identify specific research needs. Continued review of FHWA/NAPA technical working group on WMA proceedings. Submitted NCHRP proposal on expanded study into binder aging as subcontractor to Texas A&M. Contract was awarded to the Texas A&M/UCPRC team. Completed project workplan. Started collection of binder samples and binder testing. Expected major progress next quarter - Discuss workplan with Caltrans project manager. Revise work plan if required. Start workplan tasks, continuing with expanded literature review, sample collection and binder testing. • **Environmental Impacts and Energy Efficiency of Warm Mix Asphalt (SPE 4.41, TID 2366)** - Continued literature review to determine state of the practice and identify specific research needs with special reference to rubberized asphalt. Continued review of FHWA/NAPA technical working group on WMA proceedings. Reviewed laboratory testing procedures for assessing laboratory scale emissions from HMA/WMA and started apparatus design. Completed project workplan. Started collection of binder and WMA technology samples.	• **Certification of Inertial Profilers used in PMS and Construction Monitoring (SPE 3.24, TID 2364)** - Literature review and the collection of other relevant information completed. Draft of the work plan produced. Several locations identified as potential sites suitable for inertial profiler certification center. Most likely site is Edwards Air Force Base, approximately 5 hours south from Davis. SurPro3500 selected as reference profiler and sole source purchase process begun. • **Effects of Milling and Other Repairs on Smoothness of Thin Overlays (SPE 4.42, TID 2363)** - Began literature survey and work on work plan.	• **Improved Methodology for Mix Design of Open-Graded Friction Courses (SPE 3.25, TID 2362)** - Initial workplan given to PI for review. Caltrans Task Force recommendations and previous UCPRC work reviewed. Laboratory testing for mix volumetrics, Cantabro, and draindown tests underway on majority of mixes in workplan. Hamburg wheel tracking testing has been started.	• **Performance Modeling (SPE (4.43, TID 2358)** - Completed initial PaveM engineering configuration, submitted draft memo to Caltrans, reviewed with Caltrans. Worked on modeling data set. Found errors in initial UCPRC take-offs of as-builts, began review of all as-builts. Began re-analysis of PCI performance data as as-built sets were competed (by treatment type). Reviewed performance equations with Caltrans. Continue to rework data to further refine coefficients based on data and engineering judgment. Began work on memo on performance equations. - Additional work requested and completed: Rewrote APCS statement of work several times to require 3-d laser scanning for distress collection. Reviewed and helped update APCS manual to reflect Caltrans desired changes. • **Update Life-Cycle Cost Analysis Manual with New Performance Data (SPE 3.27, TID 2357)** - The pavement design function was completed for flexible pavement, including the automatic TI selection, in RealCost. The automatic M&R alternative selection processes was completed and linked to Design and Cost features. The auto-interaction between cost estimate processes and 'Alternatives/Activities' process was added.

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PROJECT UPDATES **Quarter 3** **1/31/12 to 3/31/12** **(continued)**	• **Interlayer Performance (SPE 4.34, TID 2359)** - Continued literature review and industry meetings to determine state of the practice, identify specific research needs, and which technologies should be tested. Completed workplan for project.				• **Evaluation of Compacted HMA Moisture Sensitivity (SPE 3.23, TID 2365)** - Literature review mostly completed and draft work plan prepared. Some aggregate preparation. Reproducibility and repeatability studies of Hamburg Wheel Tracking Test, HWTT and Superpave Gyratory Compactor, SGC specimens concepts being developed and to be discussed with Caltrans. Identification of test sections has started.		• **Complete QA on Automated Pavement Condition Survey and GPR contracts (SPE 3.28, TID 2354)** - Startting APCS data upload to PaveM. - Continued quality assurance of APCS data. - Analyzing existing 8 field verification sites (FVS) as Fugro image data comes in. Prepared plan for next set of APCS FVS. - Performed QA on 10,000 lane-km (6,200 lane-miles) of raw GPR/GPS data. - Performed QA on 13,600 lane-km (8,450 lane-miles) of analyzed GPR data. - Blind Verification Sections are complete (63 sections). Follow-up Verification Sections were selected (5 sections in D3 and D6). - Continued to develop, implement and test a pavement structure segmentation algorithm. Continued to incorporate the other segmentation parameters into the complete segmentation process. Segmented D3 including all parameters; segmented other 11 districts using all parameters except structure. - The truck volumes, ESALs, and TIs for the segments were calculated and added to the traffic table. 95 percent of the segments on the entire routes were completed. - Continued to assist Caltrans in the engineering configuration of PaveM. Continued to assemble and provide data to the PaveM team to perform test data imports into PaveM.

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