Challenges and Opportunities in Pavement Preservation

Public Works Officers Insitute

Monterey, CA

March 18, 2020

City and County Pavement Improvement Center

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Welcome To CCPIC

www.ucprc.ucdavis.edu/ccpic

- Funded through SB1 by:
  - Institute of Transportation Studies at UC Davis and UC Berkeley
  - Mineta Transportation Institute, San Jose State University
- Sponsored by:
  - League of California Cities
  - County Engineers of California
  - California State Association of Counties

CCPIC Mission and Vision

- Mission
  - CCPIC works with local governments to increase pavement technical capability through timely, relevant, and practical support, training, outreach and research
- Vision
  - Making local government-managed pavement last longer, cost less, and be more sustainable
- CCPIC training:
  - www.techtransfer.berkeley.edu/training/pavement-courses
  - Or go through CCPIC website

Today's Presentations

- Moderator:
  - Shadi Saadeh, CSU Long Beach
- Use of life cycle cost analysis to select and program appropriate preservation treatments
  - Sampat Kedarisetty, UC Pavement Research Center, UC Davis
- How to get maximum performance out of preservation treatments through specification and quality assurance
  - DingXin Cheng, California Pavement Preservation Center, CSU Chico
- Approaches for delivering more sustainable and multi-functional pavement
  - John Harvey, UC Pavement Research Center, UC Davis
- Questions and answers

PWOI 2020

Life Cycle Cost Analysis in Pavement Engineering

Presented by Sampat Kedarisetty, PhD Candidate, UC Davis

Introduction – Life Cycle Cost Analysis

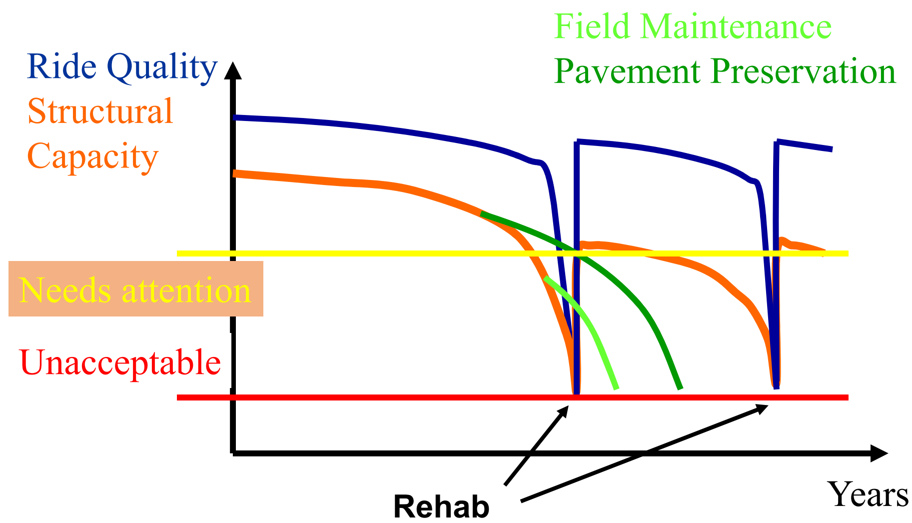
- *Shahin* described LCCA as an economic tool that can be used to analyze investments or projects that have long lives and require large amounts of capital.

- Enables comparison of long term strategies using Net Present Value (NPV) and Equivalent Uniform Annual Cost (EUAC)

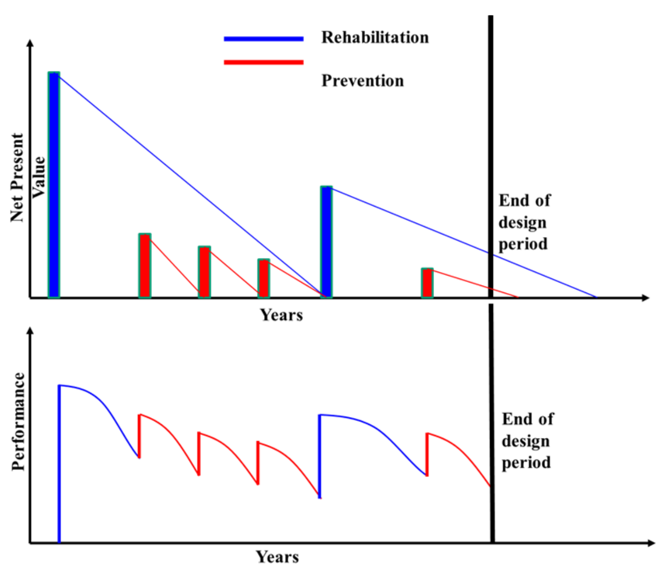
$$NPV = Initial\ cost + \sum_{k=1}^{N} Rehab\ Cost_k \left[\frac{1}{(1+i)^n}\right] - SV$$

where *i* is the Discount rate (~4%)
and *n* is the year of work for Rehab *k* and
SV is the Salvage value of any investment left at the end of the analysis period

Life Cycle Cost Analysis (LCCA) Basics



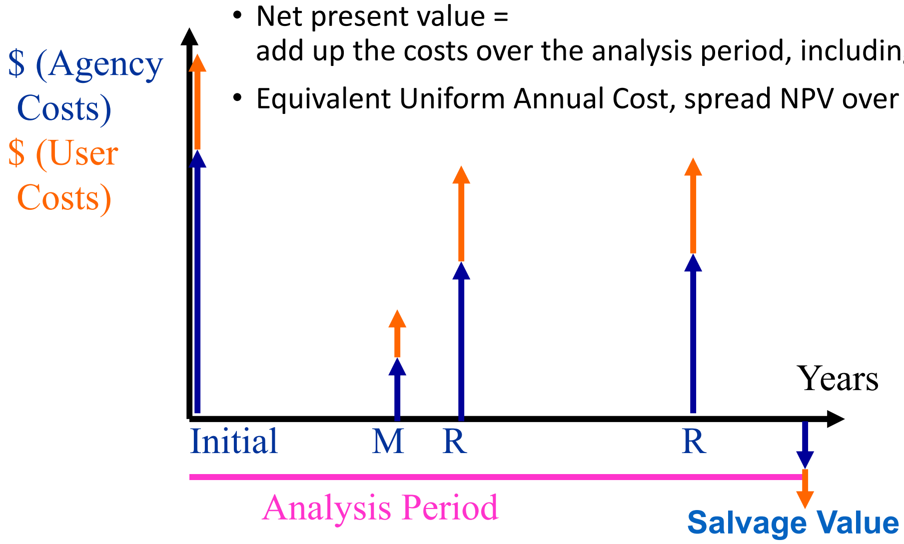
Life Cycle Cost Analysis (LCCA) Basics



Converting performance information to treatment/cost sequence

Life Cycle Cost Analysis (LCCA) Basics

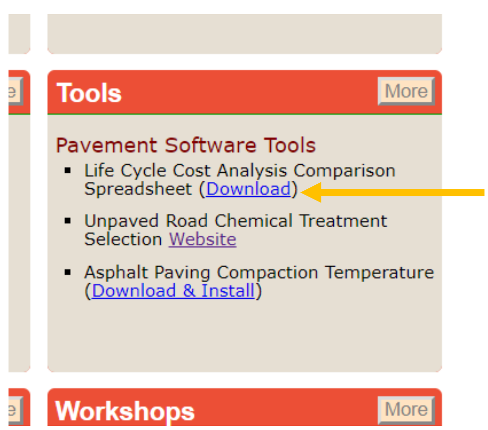
- Net present value =
  add up the costs over the analysis period, including discount rate
- Equivalent Uniform Annual Cost, spread NPV over time, with discount



Life Cycle Cost Analysis (LCCA) Tool

CCPIC LCCA Excel tool
Download at: http://www.ucprc.ucdavis.edu/ccpic/
or Google "CCPIC UCPRC"

- Excel tool to calculate Net Present Value, Salvage Value and Equivalent Uniform Annual Cost
- Can compare 3 scenarios side by side
- Can choose and edit the list and sequence of treatments



CCPIC LCCA Excel tool

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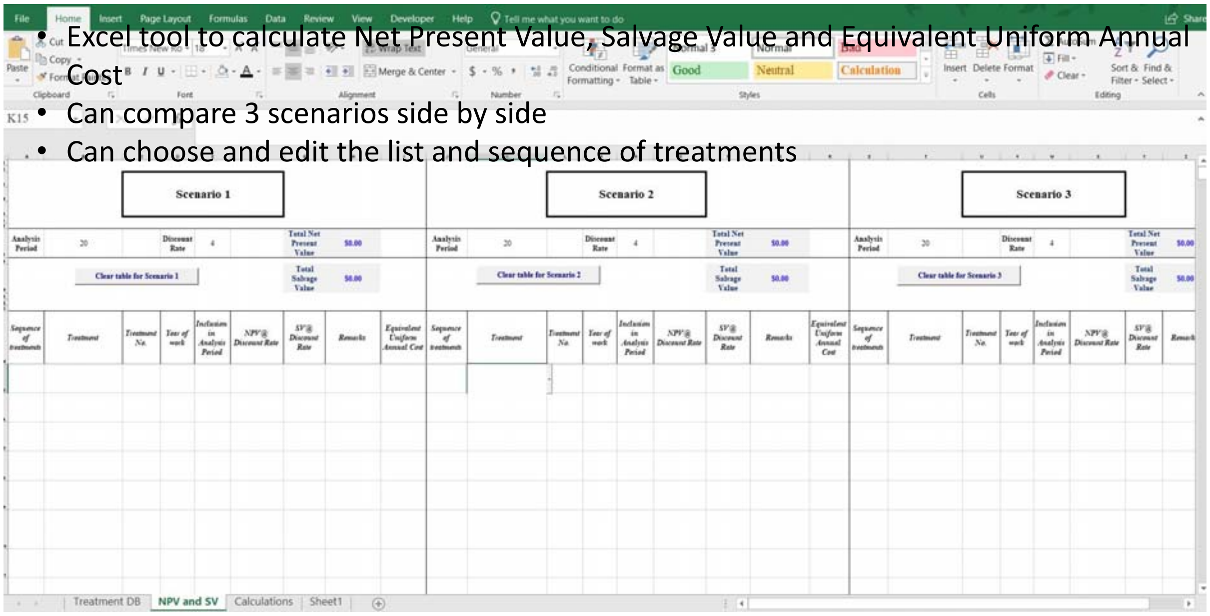
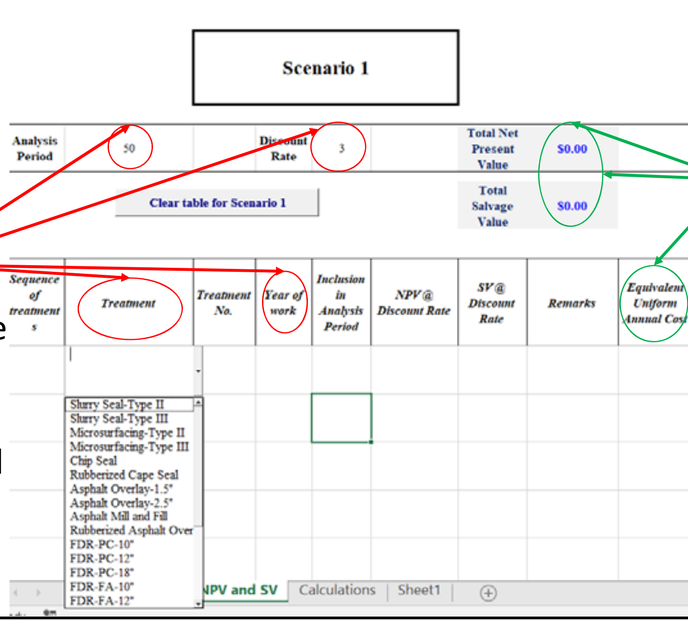


CCPIC LCCA Excel tool

Inputs

1. Treatment type
2. Year of work
3. Discount rate
4. Analysis period



Outputs

1. Total NPV
2. Total SV
3. EUAC

CCPIC LCCA Excel tool

Editable:
- Functional Unit
- Treatment List: Cost, Life of Treatment

	SY	*Lane miles*	*Width of Lane (yards)*		
Functional Unit	7040	1	4		
Treatment Name	**Treatment No.**	**Cost/SY**		**Cost/Functional Unit**	**Life of Investment**
PME chip seal	1	$ 4.50		31,680	6
AR chip seal	2	$ 6.20		43,648	8
Type II slurry	3	$ 5.50		38,720	5
Microsurfacing-Type II	4	$ 5.80		40,832	7
PME cape seal	5	$ 10.00		70,400	8
AC overlay 1.5 inches	6	$ 12.00		84,480	10
AR cape seal	7	$ 11.70		82,368	10
Asphalt Rubber Overlay 1.5"	8	$ 15.00		105,600	15
AC mill and fill 1.5 inches	9	$ 17.00		119,680	12
AC overlay 2.5 inches	10	$ 20.00		140,800	15
Asphalt Rubber Mill and Fill 1.5"	11	$ 20.00		140,800	15
Rubberized HMA-2.5"	12	$ 25.00		176,000	20
CIR-4" with thin overlay	13	$ 25.00		176,000	12
AC mill and fill 2.5 inches	14	$ 30.00		211,200	15
FDR-PC-8" + 2.5	15	$ 33.28		234,291	15
FDR-PC-10" + 2.5 AC	16	$ 40.00		281,600	20
FDR-PC-12" + 2.5 AC	17	$ 45.00		316,800	25
FDR-FA-10" + 2.5 AC	18	$ 45.00		316,800	20
FDR-FA-12" + 2.5 AC	19	$ 50.00		352,000	25

Life Cycle Cost Analysis (LCCA)

Performance prediction is key to good pavement management and LCCA

- Pavement Management Systems
  - Performance estimates are typically in terms of pavement condition index (PCI)

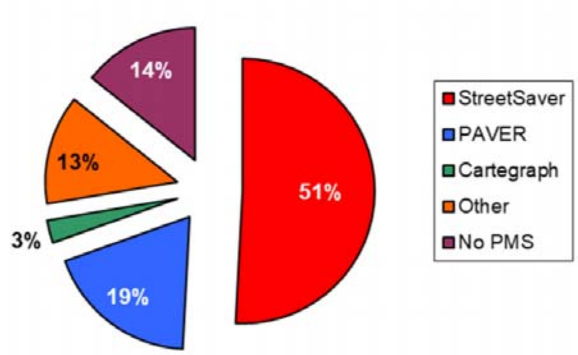
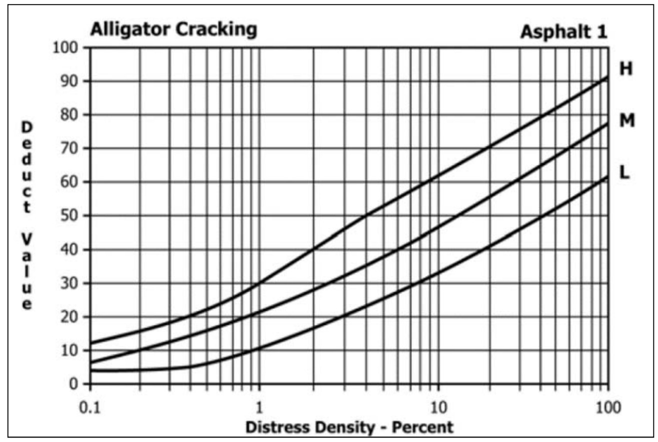


Figure B.4 PMS Software Used By Cities And Counties

Local Streets and Roads 2018

Life Cycle Cost Analysis (LCCA)-PCI

- PCI is amalgamation of different distresses
- Can have same PCI for very different conditions
- Engineering meaning in the condition survey is lost
- Recommend
  - Use PCI as communication tool for management/public
  - Manage asphalt pavement considering:
    - Cracking: age and traffic caused
    - Other distresses (rutting, raveling)



ASTM PCI manual

Life Cycle Cost Analysis (LCCA) Pilot

- Data obtained from four local government agencies for performance modeling:
  - City of San Jose
  - City of Berkeley
  - City of Mountain view
  - County of Los Angeles
- Data access obtained from the City of San Jose, Berkeley and Mountain View: Full access to download and extract all available data. More than 4 million rows of performance history and maintenance and rehabilitation history extracted

Life Cycle Cost Analysis (LCCA) Pilot

CASE 1: TRAFFIC LOADING RELATED, PCI = 34			
DISTRESS	SEVERITY	QUANTITY	DV
Alligator Cracks	High	1x6	18
Alligator Cracks	Medium	1x4 1x5 1x7	17
Potholes	Medium	3	48
Potholes	Low	3	30
Rutting	Low	2x5 2x8	10
CASE 2: AGE, CONSTRUCTION, UTILITIES, OTHER FACTORS, PCI = 32			
Long/Trans Crack	High	15 20 8 6 12 18 6x7	43
Long/Trans Crack	Medium	25x2 18 13 9 10	20
Patching/Utility	High	25x4 25x2	40
Patching/Utility	Medium	12x6 4x7	20
Block Cracks	High	4x6 6x5	13

Same PCI, different pavement condition

Life Cycle Cost Analysis (LCCA) Pilot-Observations

- Wide variation in performance depending on street type, underlying pavement structure and previous treatment
- Initial study shows agencies treating different causes of distresses similarly; pavement treatment should change according to the distresses so that the pavements remain functional longer
- Initial studies also show that treatment selection can be a major output of the pilot
- LCCA helps agencies plan for different treatments and treatment sequences

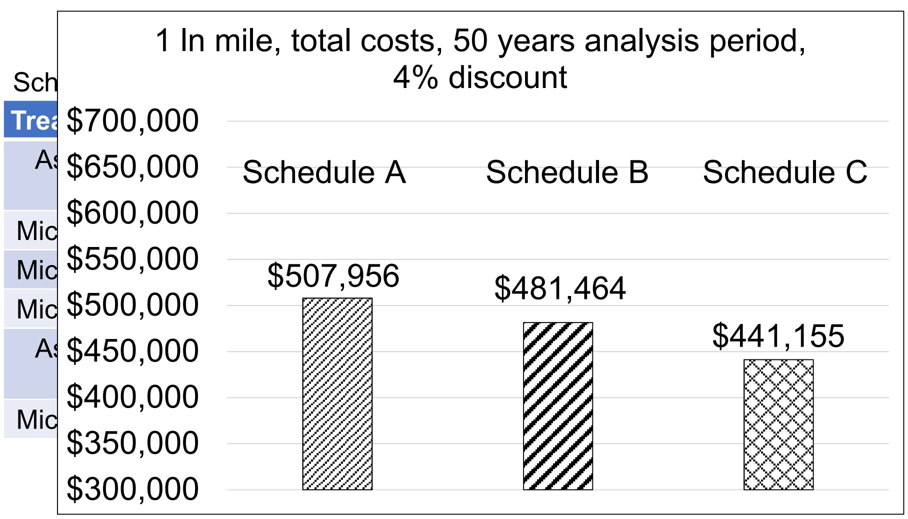
Life Cycle Cost Analysis (LCCA)

Some changes that can be considered to improve life cycle cost

- Pavement management and preservation
  - Treatment timing
  - Treatment selection
  - Treatment sequence
- Asphalt compaction

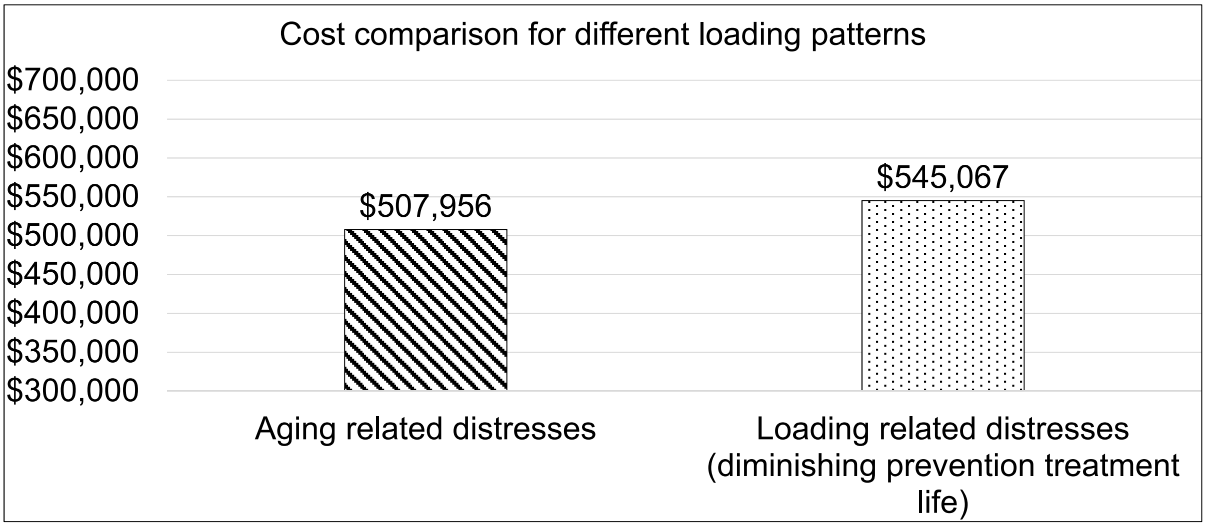
Life Cycle Cost Analysis (LCCA)-Effect of timing

Asphalt Mill and Fill - $38/SY
Microsurfacing - $14/SY



Life Cycle Cost Analysis (LCCA)-Treatment Sequences

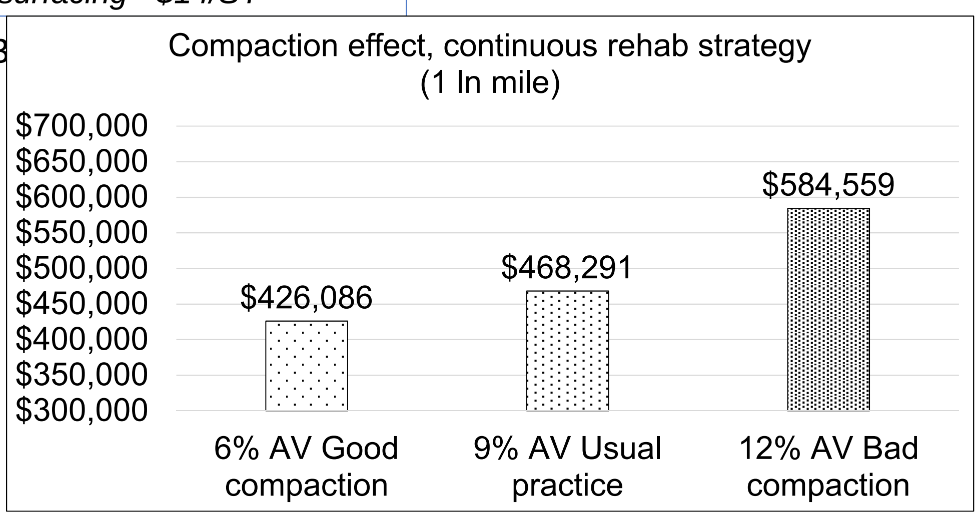
Asphalt Mill and Fill - $38/SY
Microsurfacing - $14/SY



Life Cycle Cost Analysis (LCCA)-Compaction Effects

Asphalt Mill and Fill - $38/SY
Microsurfacing - $14/SY

• 3



Life Cycle Cost Analysis (LCCA)-Summary

- LCCA can be used to provide a long-term costing perspective of maintenance and rehabilitation (M&R) activities
- LCCA has to be used in conjunction with performance estimates of M&R treatments to optimize life cycle cost
- Different treatment schedules should be chosen for different kinds of underlying distresses: Age related and Load related
- LCCA excel tool, developed by CCPIC, is free to access and use. Provides Net Present Value (NPV) and Equivalent Uniform Annual Cost (EUAC) for the treatment sequences
- LCCA can be used to inform decisions regarding:
  - Treatment timing
  - Treatment selection
  - Treatment sequences
  - Policy analysis like compaction effects

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Construction Quality Assurance Program for Pavement Preservation

By DingXin Cheng, Ph.D.
Dr. Cheng: dxcheng@csuchico.edu
Professor, California State University, Chico
Director, California Pavement Preservation Center
Associate Director, City and County Pavement Improvement Center
Presented at PWOI meeting
Monterey, CA
March 18, 2020

Slide 24

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gh8 I think this is better

Gary Hicks, 2/21/2020

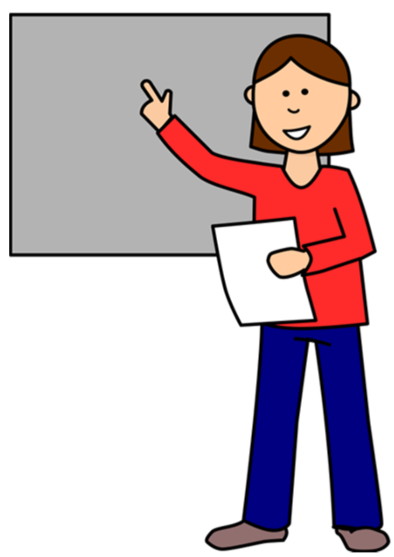
Purpose of Presentation

- Provide information on Quality Control and agency acceptance for preservation treatments
- This has been done as a part of a SB-1 project for Mineta Transportation Institute
- Treatments completed to date include
  - Chip Seals
  - Slurry Surfacings
  - Cape Seals
- Manuals can be found on the MTI website at https://transweb.sjsu.edu/csutc/research/publications
- Will use Cape Seals as an example

Overview

What are Cape Seals?

- ➢Project selection
- ➢Specifications
- ➢Test methods
- ➢Mix design
- ➢Construction
- ➢Quality Assurance



What Are Cape Seals?

- Developed originally in Capetown and they consist of two layers
- The first layer consists of an emulsion chip seal or a hot applied chip seal
- The emulsion binders can be conventional or polymer modified while the hot binders are generally asphalt rubber.
- The chips are generally ½ to ⅜ inch rock, of uniform size and good quality

What Are Cape Seals?

- The second layer is a slurry surfacing mixture of graded aggregate and asphalt emulsion binder with fillers and additives to make a cold emulsion mixture which cures quickly to a hard wearing surface.
- It can be either a microsurfacing or slurry seal
- Microsurfacing is preferred for cooler weather or night work

Project Selection

- Why use them?
  - A thin, cost effective preventative maintenance treatment.
  - Extends the life of the pavement
- Where to use them?
  - Normally on asphalt pavement, but have been used on concrete pavements showing some distresses.
  - They trigger ADA work

Project Selection

When to use them?

- Correct/improve
  - Raveling and weathering
  - Skid resistance
  - Small Cracks and voids
  - Aesthetics
- Prevent/reduce
  - Oxidation of asphalt concrete
  - Surface water infiltration
  - Pavement degradation due to the elements

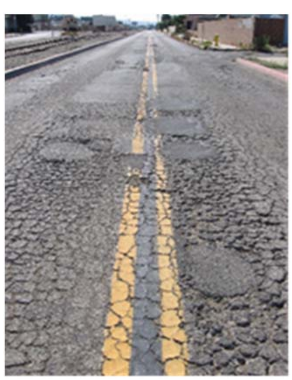
Project Selection

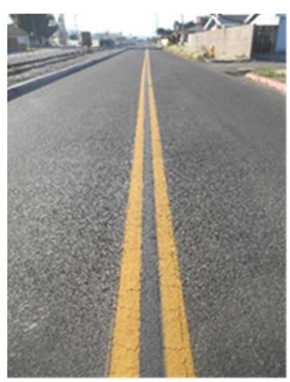
- Don't use on severely distressed pavement
  - Potholes
  - Severe alligator problems
  - Structurally deficient pavements
  - Severe rutting
  - Significant profile or cross-slope corrections

- These problems require repair work prior to cape seal surfacing.

Project Selection

- What kind of distresses can Cape seals fix?
  - A Cape seal can handle more severe distresses than a single chip seal or a single slurry surfacing.





After 8-years this Cape seal is still performing.

This is a multi-layer Cape seal at the City of Lompoc, CA

Cape Seal Surfacing Materials

First Lift

- **Chip Seal Layer**
  - **Emulsion with damp aggregate**

  or

  - **Hot applied rubber binder (AR) and hot pre-coated aggregate**

Second Lift

- **Slurry Surfacing Layer**
  - **Slurry Seal (Top Layer)**
    - **Emulsion**
    - **Aggregate**
    - **Additives**

  or

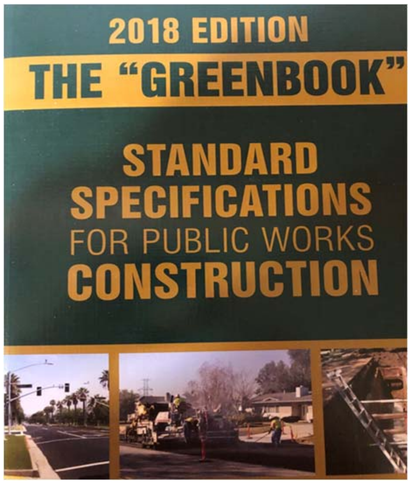
  - **Microsurfacing**
    - **Emulsion with additives for faster cure**
    - **Higher quality aggregate**

Preventing Poor Pavement Performance

- **Proper project selection**
- **Trained personnel with experience (both agency and contractor)**
- **Equipment**
  - **Good condition**
  - **Calibrated**
- **Materials and mix design**
  - **Meets specifications**
  - **Testing with accredited laboratory and certified testers**
- **Good workmanship**

Design-Specifications

- Caltrans, Greenbook, used by local agencies
  - Differences in materials specifications
  - Greenbook speaks of warranties
- If the Agency is short on inspectors, a warranty may be a good item to consider in the specifications.



Construction Topics to Cover Pre-Construction Meeting

- Contractor's QC plan and process
- Project mix designs and materials control
- Equipment calibration procedure
- Test strip for each product and location
- Quality control data
- Inspection and testing by the agency
- Documentation by both sides
- Protection of existing facilities
- Traffic control plan

Quality Control Plan (QCP)

- **Contractor is responsible for quality control (QC) sampling, testing, and documentation and needs to submit a QCP.**

- **QCP shall include sampling, testing, inspection, monitoring, documentation and submittals, and corrective action procedures during transport, stockpiling, placement, and sweeping/cleanup operations.**

- **QCP shall detail the Contractor's QC program that meets the requirements of the specifications.**

Equipment Calibration

- **Chip seal**
  - **General**
    - **Contractor to provide proof of calibration of the distributor truck and the aggregate spreader.**
    - **Calibration to be repeated once per week or after five full days of chip seal operations have been completed. (This may vary per agency)**
  - **Distributor truck**
    - **Application rates-transverse and longitudinal**
    - **Overlap- triple**
    - **Edge nozzle-at right angle**
  - **Aggregate spreader**
    - **Application rates-transverse and longitudinal**

Equipment Calibration

- **Slurry surfacings**
  - **Perform calibration and submit data for all slurry seal trucks in accordance with Caltrans Section 37-3.01C(3)(f)**
  - **Calibrate the mix paver to be used for the placement of slurry seal in the presence of the Engineer**
  - **Ensures compliance with the approved mix design/job mix formula**
  - **Each unit shall be calibrated prior to the beginning of the project for each aggregate or mixture type.**

Quality Control-Contractor

Per approved sampling and testing plan

- **Sampling and testing of the emulsion**
- **Sampling and testing of the residual binder content**
- **Sampling and testing of the aggregate**
- **Determination of the daily application rates for the mix and the quantities of emulsion, aggregate, mineral filler, water and additives**
- **Daily inspection reports**

Agency Construction Inspection

Things to do:

- **Verify application rates**
- **Take field samples from the spreader unit for water content, residual asphalt and wet track abrasion test (WTAT)**
- **Note the following**
  - **Start & stop times of operations**
  - **Traffic control & trucking operations**
  - **Curing, rolling and sweeping**
- **Prepare daily reports**

Agency - Construction Inspection

- **Workmanship Issues**
  - **Spread materials uniformly**
  - **Longitudinal joints – ensure no material buildup**
  - **Transverse joints – ensure clean joints, start and stop on roofing felt**
  - **Mixture shall be uniform in color and homogenous after spreading**
- **Sweeping to ensure removal of loose aggregate (after emulsion is cured)**
  - **Chip seals**
  - **Slurry surfacing**

Construction- Weather Restrictions for Emulsion Chip Seals and Slurry Surfacing

- Place when both pavement and air temperatures ≥ 50°F and rising.
- Do not place if air temperature is over 105°F
- No placement if rain is imminent

Construction–Applying Microsurfacing

- Allow microsurfacing to cure. Minimum of 1 hr.
- Roll microsurfacing
- Sweep the microsurfacing after rolling
- Open to traffic after initial sweeping.
- Sweep for 4 days after opening
- Sweep again after 2 weeks
- Quantify the sweepings after each day

Agency Inspection and Field Testing

- Essential items for inspector to document and detail
  - Workmanship
  - Protection of existing facilities
  - Weather—temperatures, wind conditions
  - Any problems
  - Sampling per required frequencies for each material
  - Issues to watch for with each material
  - Spread rates and temperatures of materials

Post Application Inspection

- Minimum aggregate loss
- Correct any workmanship issues
- Cleanup
- Striping
- Opening to traffic

Did Everything Work?

- What do you do if the job does not meet expectations?
  - Warranty is a good item to include in the contract specifications.
    - You can have the Contractor come back and repair it.
    - Usual period is for one year, can be longer.
    - Greenbook, Section 3-13.3
  - Specification
- Some agencies hold a bond for the warranty period.
  - Percentage of $ amount of contract.

What Do We Want to Avoid?

- Surface de-bonding
- Workmanship issues
  - Excessive drag marks
  - Poor longitudinal or transverse joints
- Tire marks from early traffic
- Excessive shedding
- Unacceptable hand work

What Do We Want?

- By following the mix designs and specifications
  - Little to no rock loss or raveling after initial period
  - Good workmanship
  - Project looks like new road
- Project should last its expected life

Approaches for Delivering More Sustainable and Multi-Functional Pavement

John Harvey, UCPRC, CCPIC, UC Davis

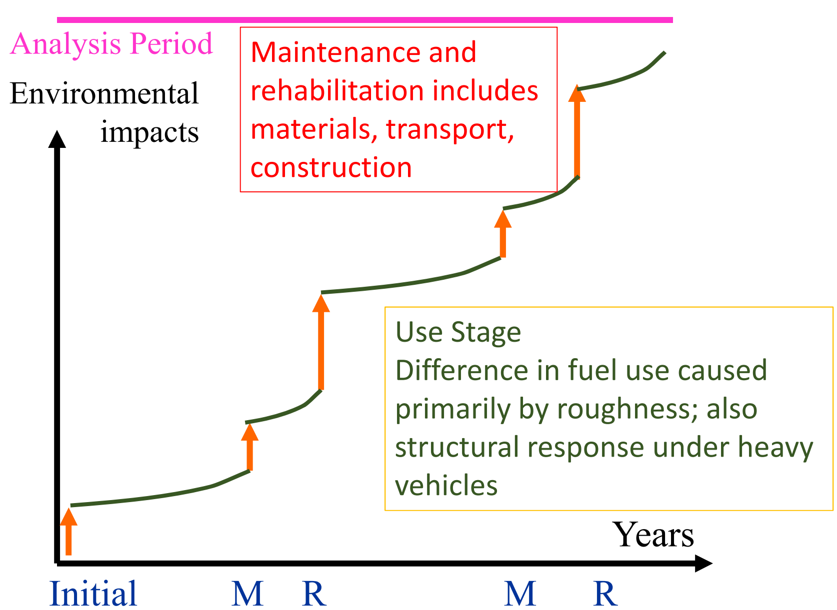
The future of local government pavements will be more sustainable and multi-functional

- Public expectations are for more sustainable and multi-functional pavements
  - State and local legislation
  - Public comments
- More sustainable:
  - Less greenhouse gas
  - Less air pollution
  - Less stormwater pollution
  - Less virgin material use
  - More use of new "sustainable" materials
- Multi-functional:
  - Bicycles
  - Cool pavement
  - Stormwater
  - Quiet

- How do we evaluate new approaches to see if they are more sustainable?
  - Economic sustainability use Life cycle cost analysis (LCCA)
  - Environmental sustainability use Life cycle assessment (LCA)
  - Quality of life measures
- To avoid unintended negative consequences we must consider:
  - Full system
  - Full life cycle

Environmental Impacts over the Pavement Life Cycle

- Where to focus
  - Lower traffic volume routes (<2500 veh/day): most impacts are <u>materials</u>, transportation, construction
  - Higher traffic routes (>2500 vehicles/day): bigger impacts from <u>rolling resistance</u> (roughness mostly)



Impacts must consider <u>full life cycle</u> and <u>full system</u> Which treatment has more environmental impacts?

- Treatment A:
  - Impact = 1000 tons greenhouse gas per year across the preservation program from materials production, transportation, construction
  - Lasts 8 years
- Treatment B:
  - 20% less initial impact than 8
  - Lasts 5 years
- Impact comparison over 20 year analysis period:
  - Treatment A: 20,000 tons
  - Treatment B: = 20,000 tons*(1-0.2)*8/5 = 25,600 tons
- Conclusion: Treatment A produces less impact over the life cycle

Impacts must consider <u>full life cycle</u> and <u>full system</u> Which treatment has more environmental impacts?

- Where do the environmental impact numbers come from?
  - Materials production and construction first-order numbers from Caltrans PMS are currently available
    - Contact CCPIC@ucdavis.edu
  - ITS Davis SB1/UCPRC funded LCA tool for local government is being developed and should be available by end of summer
  - Environmental Product Declarations (EPD) for materials production
- Where do the treatment lives come from?
  - Best if come from agency review of performance
  - Can also use performance curves in your pavement management system
  - Use the same information used for life cycle cost analysis

Environmental Product Declaration (EPD)

- Results of an LCA for a product, cradle to gate of plant
- Published by materials producer following industry rules

Adapted from Pavement Interactive, Steve Muench

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

Why Would a Local Government Ask for EPDs? Can Industry Deliver Them?

- EPDs provide a means for agencies to begin to <u>quantify</u> their emissions and impacts
- Asphalt and concrete producers have set up systems to produce verifiable EPDs
  - Including asphalt rubber and other types of asphalt, different types of concrete
- If new products are being considered this would be a good thing to ask for
  - Starts to help sort out unsubstantiated and potentially incomplete environmental claims
  - Cool pavement coatings, plastic in asphalt, extremely high RAP mixes with high rejuvenator content, etc

NRMCA™

NAPA
NATIONAL ASPHALT PAVEMENT ASSOCIATION

Are we ready to begin using EPDs for selecting materials suppliers?

Mukherjee et al,
http://www.ucprc.ucdavis.edu/PDF/FHWA_EPD_Workshop_Report.pdf

Recommendations from FHWA/Industry EPD Workshop, Michigan, 2016

- Start requiring, develop rules/reporting, standardization of EPDs (1-2 years)
  - Learning period for industries and agency
- Require use of standardized EPDs (3 to 5 years)
  - Pressure industries to harmonize their reporting
  - Make sure numbers are verifiable and comparable: level playing field for competition
- Once have good numbers coming from industry, consider for procurement
  - Caltrans and California High Speed Rail are moving down this path
  - Some local governments are already considering procurement

Actionable now: Timely use of preservation Example for urban street

- Timely use of preservation treatments can postpone AC mill and fills
  - Timely = when beginning to age, before cracking
  - Usually about 10 to 15 years

Treatment	Approximate Metric Tons GHG/lane mile
Slurry Seal	4
2.0 inch HMA mill and fill	45
6.0 inch HMA remove and replace	161

LCCA and LCA results: Urban alternatives

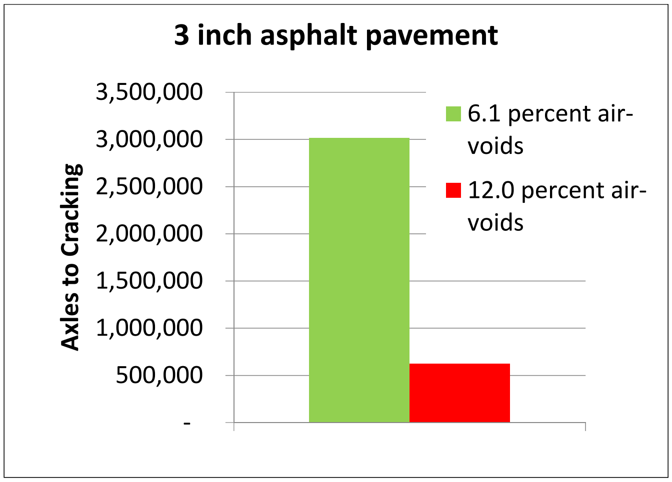
Mill and Fill Scenario	$/sy	Year
HMA 2 inch mill and fill	38	0
HMA 2 inch mill and fill	38	20
HMA 2 inch mill and fill	38	40
Remove and Replace Scenario	$/sy	Year
HMA 2 inch mill and fill	52	0
Remove, replace 6 inches HMA	52	25
Preservation Scenario	$/sy	Year
HMA 2 inch mill and fill	38	0
Slurry seal	7	12
Slurry seal	7	19
Slurry seal	7	26
HMA 2 inch mill and fill	38	33
Slurry seal	7	45

- 50 year analysis, 2% discount rate
- Remove and replace:
  - 14% more cost
  - 60% more GHG
- Preservation:
  - 12% less cost
  - 27% less GHG

GHG adapted from A. Saboori doctoral thesis, 2020

Actionable now: Asphalt Compaction Quality Control

Effect of asphalt construction compaction on axle loads to cracking



Simulation based on FHWA Westrack project field results

General rule:
1% increase in constructed air-voids = 10% reduction in fatigue life under heavy loads

Similar effects on residential routes; more air voids = faster aging

Local Government LCCA and LCA example: Asphalt Compaction 8% vs 12% air-voids

- Assumptions:
  - 4 miles of two-lane rural county road
  - Pulverize cracked HMA, compact, 100 mm HMA overlay
  - $26/sy
  - 12% air-voids = 12 year life
  - 8% air-voids = 18 year life
- Net present cost* over 50 year period:
  - 12% air-voids = $4.36 million
  - 8% air-voids = $3.09 million = **29 % less cost**
- Greenhouse gas emissions are **34% less**

*2% discount rate

How to Get Good Asphalt Compaction

- Include QC/QA construction air-void content specification in each contract
- Measure air voids as % of Theoretical Maximum Density
  - Not laboratory test maximum density
- Have contractor prove they can achieve spec
- Measure every day
- Look at the data
- Communicate with contractor
- If not following these steps, likely getting 10 to 13% air voids

On CCPIC web site!


Best Practices for Pavement

Is your asphalt only living half as long as it could?

UCPRC
UNIVERSITY of CALIFORNIA | PAVEMENT RESEARCH CENTER
Davis • Berkeley

City and County Pavement Improvement Center

Writing and enforcing specifications for asphalt compaction

May 2017

Actionable now: use of thinner RHMA overlays Greenhouse Gases HMA vs RHMA

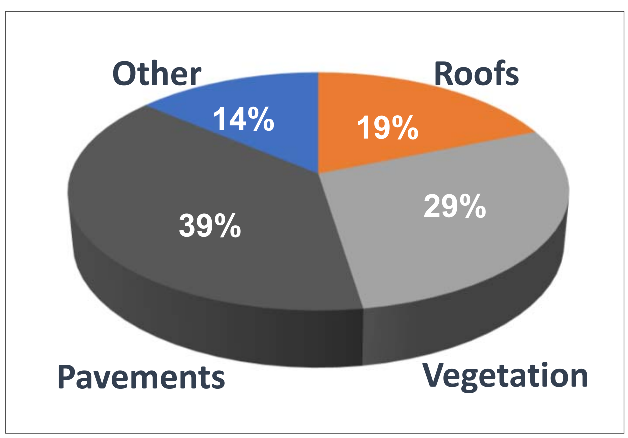
Adapted from T. Wang doctoral thesis, 2013

- Same design for 10 year overlay on highway
- HMA strategy emits 26% more greenhouse gases because of increased thickness

Strategy for Overlays	Materials (MTons GHG)	Construction and Transport (MTons GHG)	Total (MTons GHG)
2 inch mill + 3 inch HMA with 15% RAP	1,650	505	2,155
1.25 inch mill + 2.25 inch RHMA	1,310	396	1,706
HMA/RHMA	1.26	1.28	1.26

Challenge for the Future: Multi-functionality

- Traditional goal:
  - Smooth pavement for vehicles at lowest cost
- Pavement dominates the urban landscape



Sacramento

Fractions of land area were measured above tree canopy

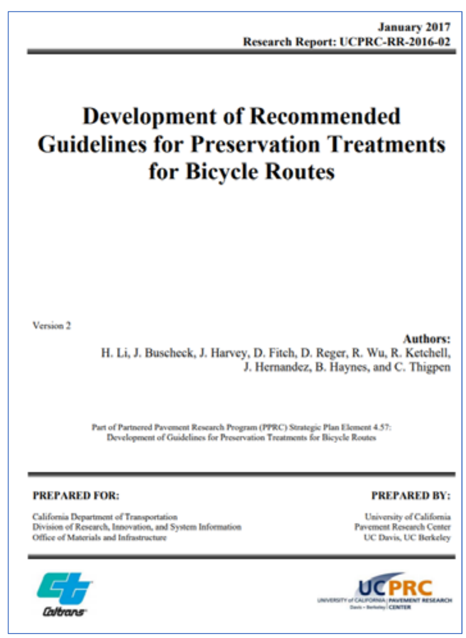
Akbari et al. 2003 <doi:10.1016/S01692046(02)00165-2>

Challenge for the Future: Multi-functionality

- New goals from the public and potential solutions
  - Bicycles
    - Reconfigure to include bike lanes when restriping preservation treatments
    - Selection of treatments to improve bicycle ride quality
    - Minimize cracking and roughness through preservation
  - Cool pavement
    - Balance reflectivity to improve human thermal comfort
  - Stormwater
    - Consider permeable pavement
  - Quiet
    - Raveling and roughness increase noise
    - Manage through timely preservation

Consideration of Bicyclists When Choosing Preservation Treatments

- Caltrans sponsored study
- More than 100 riders surveyed state, county and city pavements
  - HMA
  - Slurry, microsurfacing
  - Chip seals
- County and city roads
- Conclusions:
  - Minimize cracking and roughness with preservation
  - Do not select high texture seal coats
- Guidance on seal coat spec selection: http://www.ucprc.ucdavis.edu/PDF/UCPRC-RR-2016-02.pdf



January 2017
Research Report: UCPRC-RR-2016-02

Development of Recommended Guidelines for Preservation Treatments for Bicycle Routes

Version 2

Authors:
H. Li, J. Buscheck, J. Harvey, D. Fitch, D. Reger, R. Wu, R. Ketchell, J. Hernandez, B. Haynes, and C. Thigpen

Part of Partnered Pavement Research Program (PPRC) Strategic Plan Element 4.57: Development of Guidelines for Preservation Treatments for Bicycle Routes

PREPARED FOR:
California Department of Transportation
Division of Research, Innovation, and System Information
Office of Materials and Infrastructure

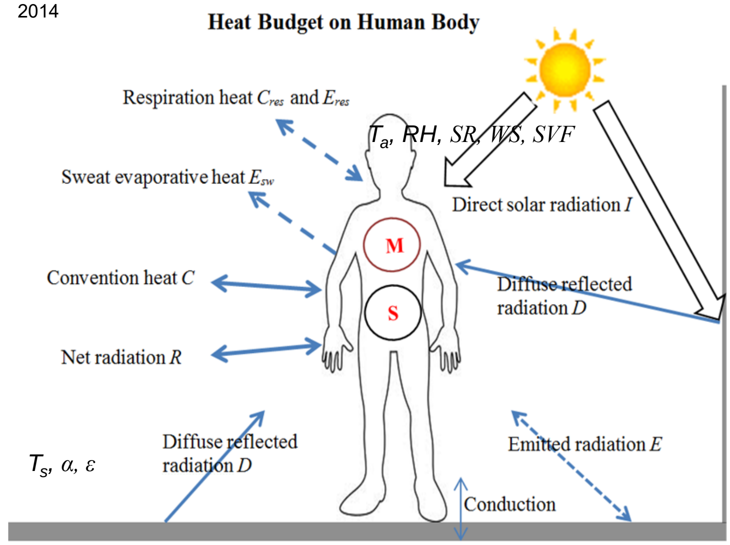
PREPARED BY:
University of California
Pavement Research Center
UC Davis, UC Berkeley

Cool Pavement Considerations

- California Air Resources Board/Lawrence Berkeley National Laboratory, UCPRC, USC, thinkstep study
  - Reflective coatings for cool pavement can substantially increase greenhouse gas emissions over life cycle compared with slurry seals
  - Case study examples for Los Angeles and Fresno
  - Reflective coatings can require up to six times more energy than a slurry over 50 year analysis period
  - https://newscenter.lbl.gov/2017/05/18/not-all-cool-pavements-are-created-equal/
- UCPRC study on human thermal comfort
  - Increased reflectivity reduces pavement temperatures
  - Also increases reflected energy onto people and objects

Li et al. (2014) Study of Cool and Reflective Pavement Conclusions:
- Focus on human thermal comfort, not reduced electricity use
- Use cooler pavements with low GHG
- For thermal comfort must balance pavement heat and reflected energy

Li et al
2014



M is the metabolic rate (W/m^2). *W* is the rate of mechanical work (W/m^2). *S* (W/m^2) is the total storage heat flow in the body.

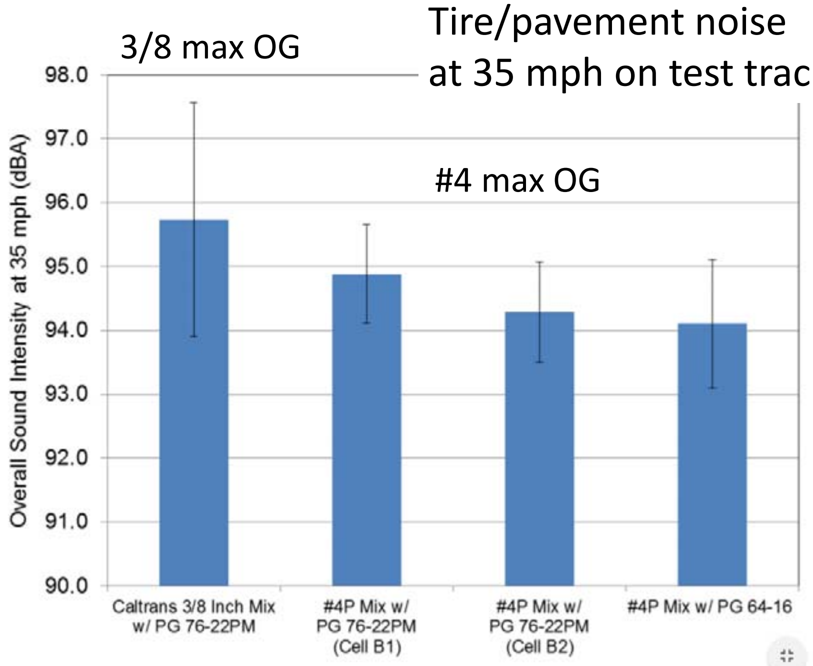
Fully Permeable Pavement Design Methods

- Pervious Concrete and Porous Asphalt for Heavy Truck Traffic
  - Preliminary permeable pavement designs for typical California traffic and environmental conditions
  - Includes use of permeable concrete subbase
  - http://www.ucprc.ucdavis.edu/PDF/UCPRC-RR-2010-01.pdf
- Permeable Interlocking Concrete Pavement for Heavy Truck Traffic
  - Design method and validation results
  - Being incorporated into ICPI and ASCE designs
  - http://www.ucprc.ucdavis.edu/PDF/UCPRC-RR-2014-04.pdf

Small stone open-graded mixes

- Can reduce tire/pavement noise
- More durable than Caltrans OG
- Can slow stormwater runoff

Tire/pavement noise at 35 mph on test track



Conclusions

- Better pavement practices can help reduce climate change, and often also reduce cost
- LCA and LCCA are tools to be used to quantify and prioritize
- Evaluate current practices and new alternatives considering full system and life cycle
- There are strategies that you can be implementing now!
  - Timely preservation
  - Better asphalt compaction
  - Rubberized overlays
  - Start asking for EPDs
- Multi-functionality
  - Pavement for bicycles
  - Cool pavements: select low GHG treatments, balance reflectivity for comfort
  - Consider permeable pavement, small stone open-graded mixes

Questions?

UCPRC | City and County Pavement Improvement Center

Welcome To CCPIC

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