City and County Pavement Improvement Center (CCPIC)

Pavement Financial and Environmental Sustainability, Some Best Practices

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San Diego County
Building Better Roads Working Group
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Welcome To CCPIC

- Sponsored by League of California Cities, County Engineers Association of California, and California State Association of Counties
- Chartered 28 September 2018

www.ucprc.ucdavis.edu/ccpic

Agenda

- Welcome and Introductions
- CCPIC:
  - Mission and Vision, Scope, Organization
  - Certificate Program
  - Planned Certificate Curriculum and New Course Development
- Worklist
- Technical Presentation
- Questions and Answers

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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 Organization

- University of California Partners
  - University of California Pavement Research Center (lead), administered and funded by ITS Davis
  - UC Berkeley ITS Tech Transfer, administered and funded by ITS Berkeley

- California State University Partners
  - CSU-Chico, CSU-Long Beach, Cal Poly San Luis Obispo
  - Funding partner: Mineta Transportation Institute, San Jose State University

CCPIC Organization

- Governance:
  - Chartered by League of California Cities, California State Association of Counties, County Engineers Association of California, also provide staff support
  - Governance Board consisting of 6 city and 6 county transportation professionals
- Current Funding
  - Seed funding for CCPIC set up and initial activities from SB1 funding through the ITS at UC Davis and UC Berkeley, and Mineta Transportation Institute at San Jose State University

CCPIC Scope

- Technology Transfer: training
- Technical resources: technical briefs, guidance, sample specifications, tools, and other resources
- Pavement engineering and management certificate program for working professionals: through UC Berkeley ITS Tech Transfer
- Resource center: outreach, questions, pilot study documentation, and forensic investigations
- Research and development: for local government needs that are not covered by State and Federal efforts

CCPIC Training: Certificate Program

- Pavement Engineering and Management Certificate Overview
  - For engineers, asset managers, upper-level managers, technicians and construction inspectors
  - 92 hours of training
    - 60 hours in core classes, 32 hours elective
    - Majority of classes to be offered online
  - In four categories:
    - Pavement Fundamentals
    - Pavement Management
    - Pavement Materials and Construction
    - Pavement Design

Status

- Plan approved by Governance Board
- Initial classes being delivered, including updated Tech Transfer classes and newly developed classes

CCPIC Training: Planned Certificate Curriculum

	Fundamentals		Hrs	Management		Hrs	Materials and Construction		Hrs	Design		Hrs
CORE 60 required	CCA-01	Introduction to Pavement Engineering and Management	10	CCB-01	Life Cycle Cost Analysis	4	CCC-01	Asphalt Concrete Materials and Mix Design	8			
	CCA-02	Pavement Sustainability	6	CCB-02	Pavement Management Systems and Preservation Strategies	16	CCC-02	Pavement Preservation Materials and Treatments	8			
							CCC-03	Pavement and Hardscape Construction Specifications and Quality Control Management	8			
	Fundamentals, CORE		16	**Management, CORE**		20	**Materials and Construction, CORE**		24	**Design, CORE**		0
ELECTIVE 32 required 106 offered				CCB-21	Financing and Cash Flow for Pavement Networks	4	CCC-21	Concrete Materials	8	CCD-21	Asphalt and Concrete Pavement and Rehabilitation Structural Design	16
				CCB-22	Integrated Asset Management	8	CCC-22	In-Place Recycling	8	CCD-22	Design of Integrated Hardscape Assets	8
							CCC-23	Gravel Roads Engineering, Construction, and Management	8			
							CCC-24	Asphalt and Concrete Pavement Construction Processes and Scheduling	6			
							CCC-25	Construction Inspection	16			
							CCC-26	Pavement and Hardscape Construction Inspection	8			
							CCC-27	Asphalt Pavement Maintenance Construction	8			
							TS-10	Work Zone Safety	8			
	Fundamentals, ELECTIVE		0	**Management, ELECTIVE**		12	**Materials and Construction, ELECTIVE**		70	**Design, ELECTIVE**		24
TOTAL	**Fundamentals**		16	**Management**		32	**Materials and Construction**		94	**Design**		24

CCPIC Training: New Course Development

Code	Title	Instructor(s)	Expected	Format	Duration
CCA-01	Introduction to Pavement Engineering and Management	Harvey	Completed	Online	10 hours
CCA-02	Pavement Sustainability	Harvey	Summer 2020	Online	6 hours
CCB-01	Pavement Life Cycle Cost Analysis	Hicks, Cheng	Completed	Online	4 hours
CCB-02	Pavement Management Systems and Preservation Strategies	Yapp, Signore	Completed Spring 2021	Classroom Online	16 hours TBD
CCC-01	Asphalt Concrete Materials and Mix Design		Summer 2021	Online	8 hours
CCC-02	Pavement Preservation Materials and Treatments	Hicks, Cheng	Late Fall 2020	Online	8 hours
CCC-03	Pavement and Hardscape Construction Specifications and Quality Control Management		Fall 2021	TBD	8 hours
CCC-23	Gravel Roads Engineering, Construction, and Management	Jones	Spring 2021	Online	8 hours

Worklist

- **Pavement Condition Index (PCI) 4-Pager**
  - A four page paper describing how PCI is measured, what it doesn't measure, and how a similar or the same PCI for different road segments may have different implications for pavement preservation and pavement rehabilitation strategies.
  - *Issue October 2020*

- **Tech Topics/Pavement Technology Updates**
  - Review the publications from 1998 through 2011. Prioritize for editing, updating, and posting on the CCPIC web site.
  - *In Progress*

Worklist

- **Superpave Lite (“Hot Mix Asphalt – Local Government” [HMA- LG])**
  - Lead the development of specifications for a Superpave specification for use by local agencies.
  - Establish mix design criteria and other appropriate technical requirements.
  - First version a restructured and edited version of Caltrans Section 39.
  - *Draft version in progress. Expected first draft to be submitted to Cal APA for comments in mid-October.*

Worklist

- **Local Agency Survey:**
  - Conduct a survey of local agencies on the use of Superpave, interest in a Superpave specification, RAP, warm mix, and other related . Develop a contact list of each Agency's "go to" person. Results will provide insight and serve as a basis for future CCPIC initiatives.
  - *In Progress*

Worklist

- Interested in being on the "Go to" list?

  ✓ Go to the CCPIC website. Under "Pavement Contact List", click on "Click to join …" and complete the form. Thank you!

Proposed New Technical Projects

- **Site Investigation Guidance Manual**
    - Prepare and publish a site investigation guidance manual for local agency projects based on the manual currently being developed for Caltrans. Contents will include a discussion of destructive and non-destructive tests and frequencies.
    - *Begin review and editing once Caltrans version is complete.*

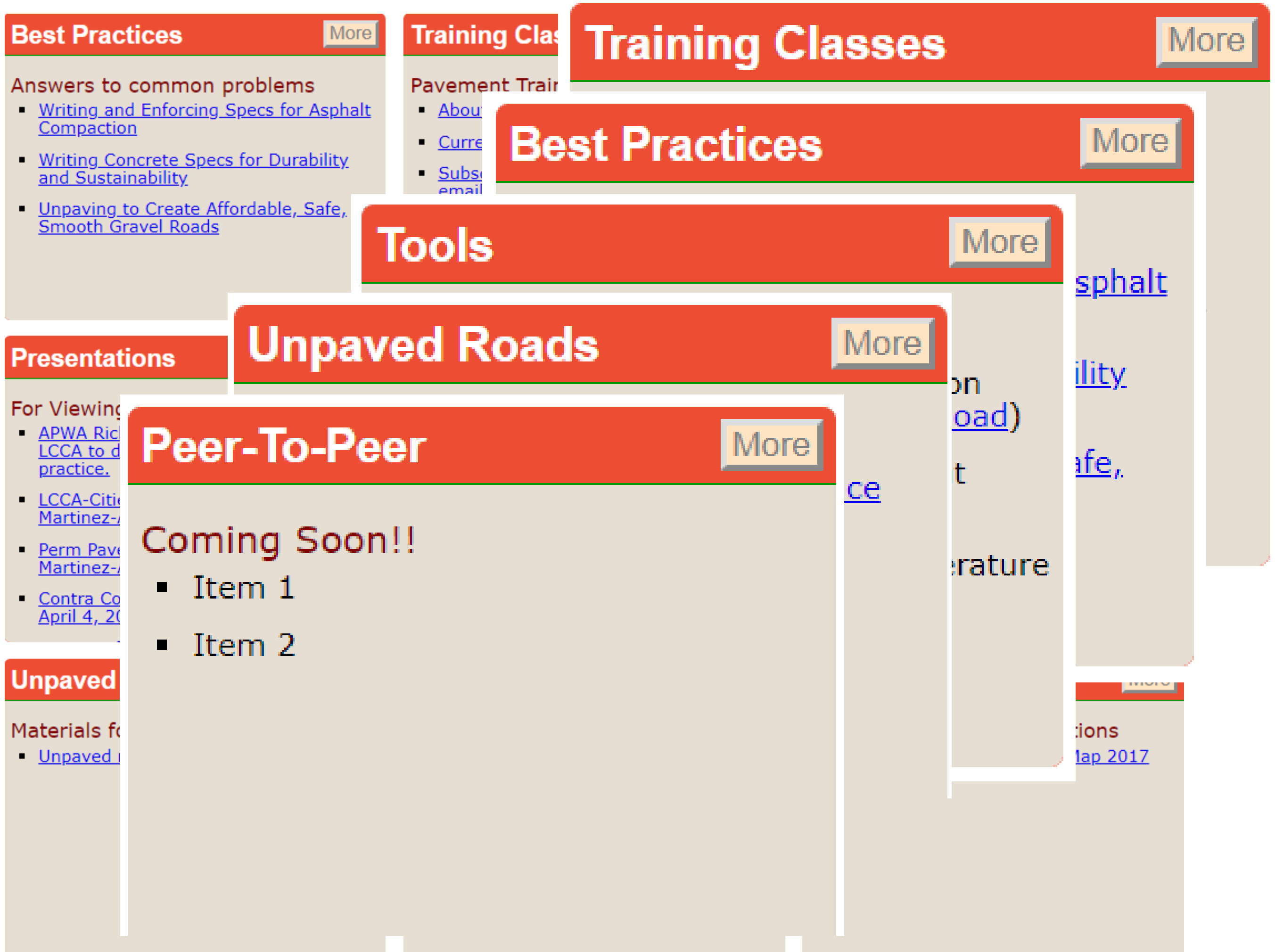
- **Specifications for Cold-In-Place and Cold Central Plant Recycling**
    - Review current Caltrans and local agency specifications. Prepare specifications suitable for statewide adaptation. Address processes using engineered emulsion and foamed asphalt.
    - *Begin once UCPRC completes research, analysis, and recommendations, and publishes report for Caltrans.*

Proposed New Technical Projects

- **Reclaimed Asphalt Pavement (RAP) 101**
  - Prepare and publish a four-page technical brief on RAP, its effect on PG binder grades and HMA/AC mixtures, percent binder replacement, fractionation, and recycling agents.
  - *Begin once PCI 4-pager is published and posted.*

- **Long Life/Perpetual Pavements for Local Agencies**
  - Prepare and publish a four-page technical brief on the fundamentals and principles of long life and perpetual pavements and how they can be applied to Local Agency projects.
  - *Not scheduled*

CCPIC Website
www.ucprc.ucdavis.edu/ccpic



- Pavement training
- Best practices technical briefs
- Tools
- Unpaved roads
- Peer-to-peer

How to get involved?

- Get training
- Get your organization to take training
- Host in-person training classes
- Read the tech briefs and see if your agency can make improvements
  - See the draft specification language
  - We can support you
- Get involved with governance board
- Start a peer-to-peer chat group
- Take a look at the tools on the website

How to figure out most cost-effective strategies: Use PMS data and life cycle cost analysis

- Understanding performance of your pavements is key to good pavement management and life cycle cost analysis (LCCA)
  - Performance estimates are typically in terms of pavement condition index (PCI)
  - Agencies need to go one step behind PCI to understand performance, can do this themselves

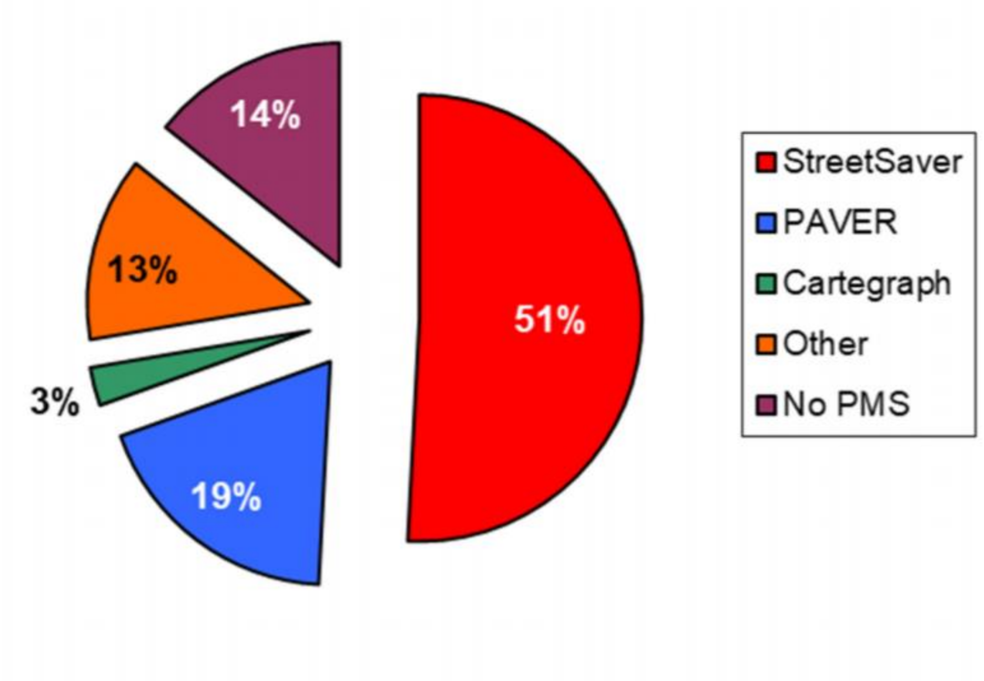
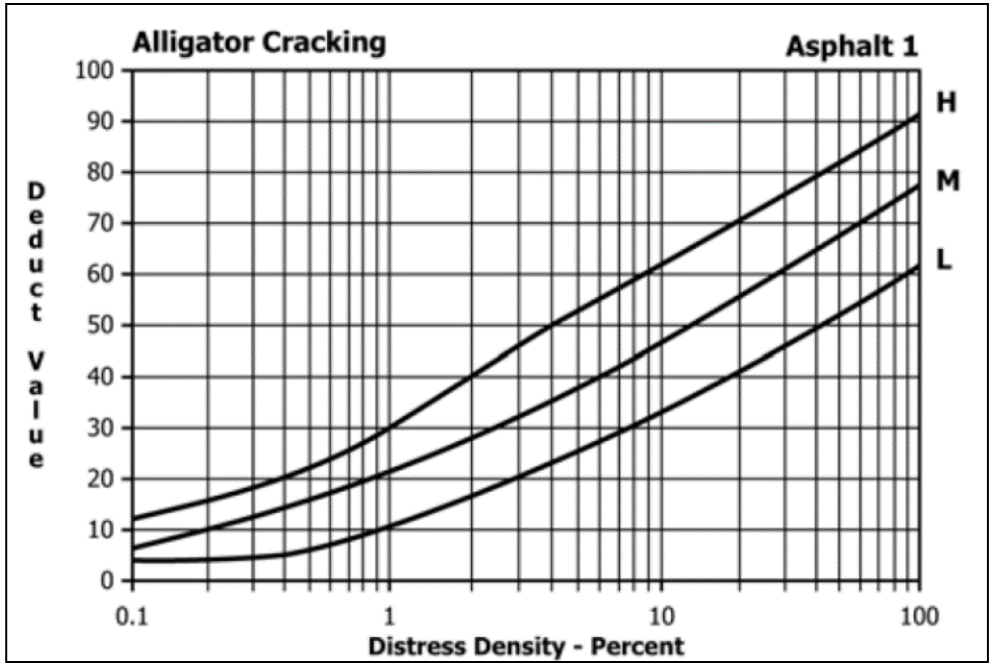


Figure B.4 PMS Software Used By Cities And Counties

Local Streets and Roads 2018

Pavement Management: Use of PCI vs. Measured Cracking

- 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)
- CCPIC working on Tech Brief regarding use of PCI and cracking data



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Same PCI, different pavement condition:

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	15x20 8x6 12x18 6x7	43
Long/Trans Crack	Medium	25x2 18x13 9x10	20
Patching/Utility	High	25x4 25x2	40
Patching/Utility	Medium	12x6 4x7	20
Block Cracks	High	4x6 6x5	13

Variables in the PCI for Asphalt Pavement

- Fatigue cracking and potholes caused by <u>heavy loads</u>:
  - Alligator cracking
  - Potholes
- Cracking caused by <u>aging</u>:
  - Block cracking
  - Joint reflections
  - Longitudinal and transverse cracking

- Other distresses
  - Low ride quality
  - Bleeding
  - Bumps and sags
  - Corrugations
  - Depressions
  - Edge cracking
  - Lane/shoulder drop-off
  - Patching and utility cut patching
  - Polished aggregate
  - Rutting
  - Shoving
  - Slippage cracking
  - Swelling
  - Weathering and raveling

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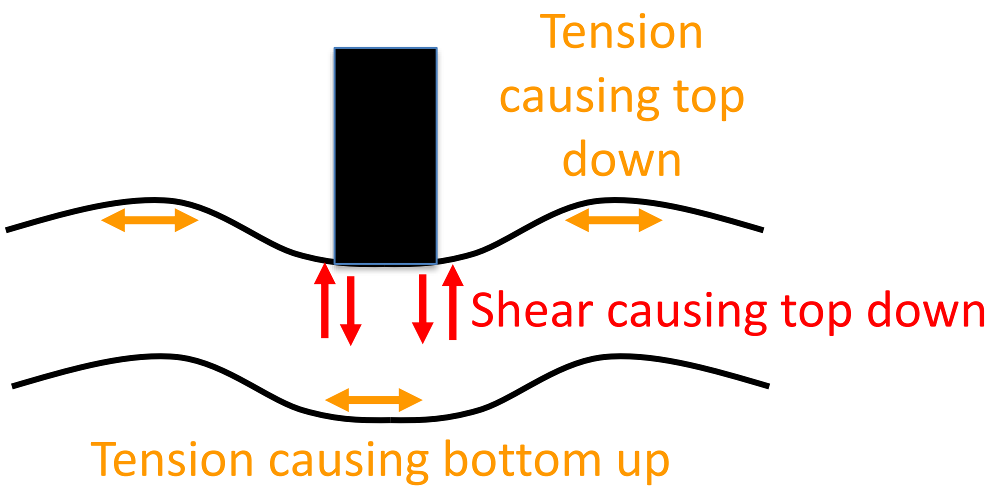
Bottom-Up Fatigue Cracking

- Interaction of asphalt concrete layer, support of underlying structure, materials selection, construction compaction
- Traffic loading
  - Only the truck loads count, cars are too light
  - slower speeds = longer durations = bigger strains
- Environment
  - temperature
  - water sensitivity
  - aging

Top-Down Fatigue Cracking

- Identified in the 1990s
- Cracking due to high tensile and shear stresses at the HMA surface near edges of truck tires



Top-Down Fatigue Cracking

- Thin HMA (< 4"): Fatigue cracking generally starts at the top
- Thick HMA (≥ 4"): Fatigue cracking generally starts at the bottom
  Note, thickness of AC in photo on the previous slide is 20"
- Traffic loading: High truck tire pressures

Initial Wheel Path Cracking (transverse or longitudinal)

- Distress descriptions can be seen in FHWA Distress Identification Manual and
- Maintenance Technical Advisory Guide, Volume I, Chapter 1

Cracks connected: Alligator Cracking

Fatigue Cracking in Wheel Paths

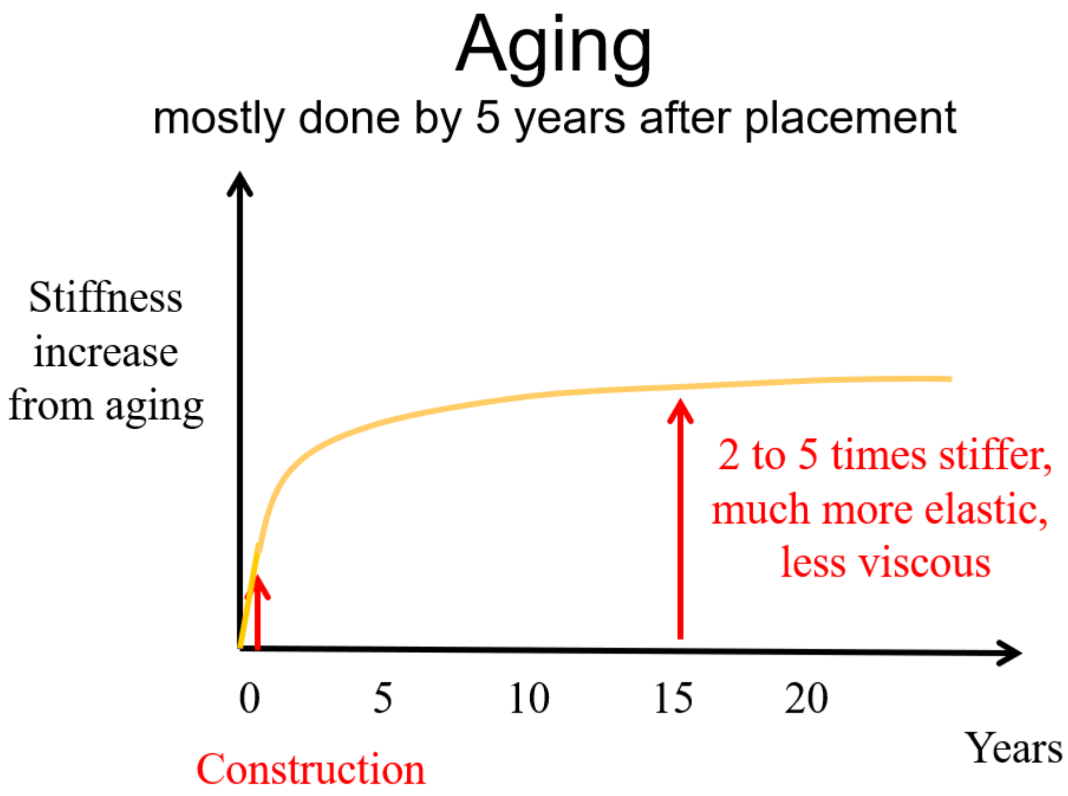
Treatment for Load-Related Fatigue Cracking

- Fatigue cracking becomes alligator cracking, and eventually forms potholes
- Surface treatments will slow a little, but mostly helps with block cracking, not fatigue
- Will need to do periodic mill and fill with digouts of localized deep cracking
- Mill and fill may not be cost-effective once alligator cracking is extensive
  - Consider partial-depth or full-depth reclamation (FDR) cold in-place recycling depending on crack depth
- Do not let wheelpath cracking become extensive or must reconstruct

Extensive and likely deep alligator cracking,
Starting to form potholes

Aging of the Asphalt

- Aging of the asphalt
  - Caused by oxidation, volatilization
  - Faster if high permeability and temperature
  - Permeability greatly reduced with better asphalt compaction
- Effects
  - Stiffening of mix with time
  - Won't relax stresses from thermal contraction as well



Block Cracking

- Typically caused by long-term aging of asphalt concrete and daily temperature cycling (expansion/contraction)
- May also be reflection cracking from shrinkage cracks in cement treated base
- Poor asphalt construction compaction allows air to enter and age the asphalt faster, accelerates aging

Good compaction limits entry of air and slows oxidation

Block Cracking

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Treatment for age-related cracking:

- Keep the surface protected from aging
- Can potentially use perpetual fogs, slurries or microsurfacings
  - Use appropriate treatment for HMA or RHMA
- What frequency?
  - After aging has progressed
    - About 7 to 12 years
  - Before cracking starts
    - Do not let cracking get extensive
  - Doing more frequently than needed can be a waste

Other Distresses: Delamination/Debonding

- Due to insufficient tack coat application.

- Accelerated by poor compaction leading to higher air voids and permeability.

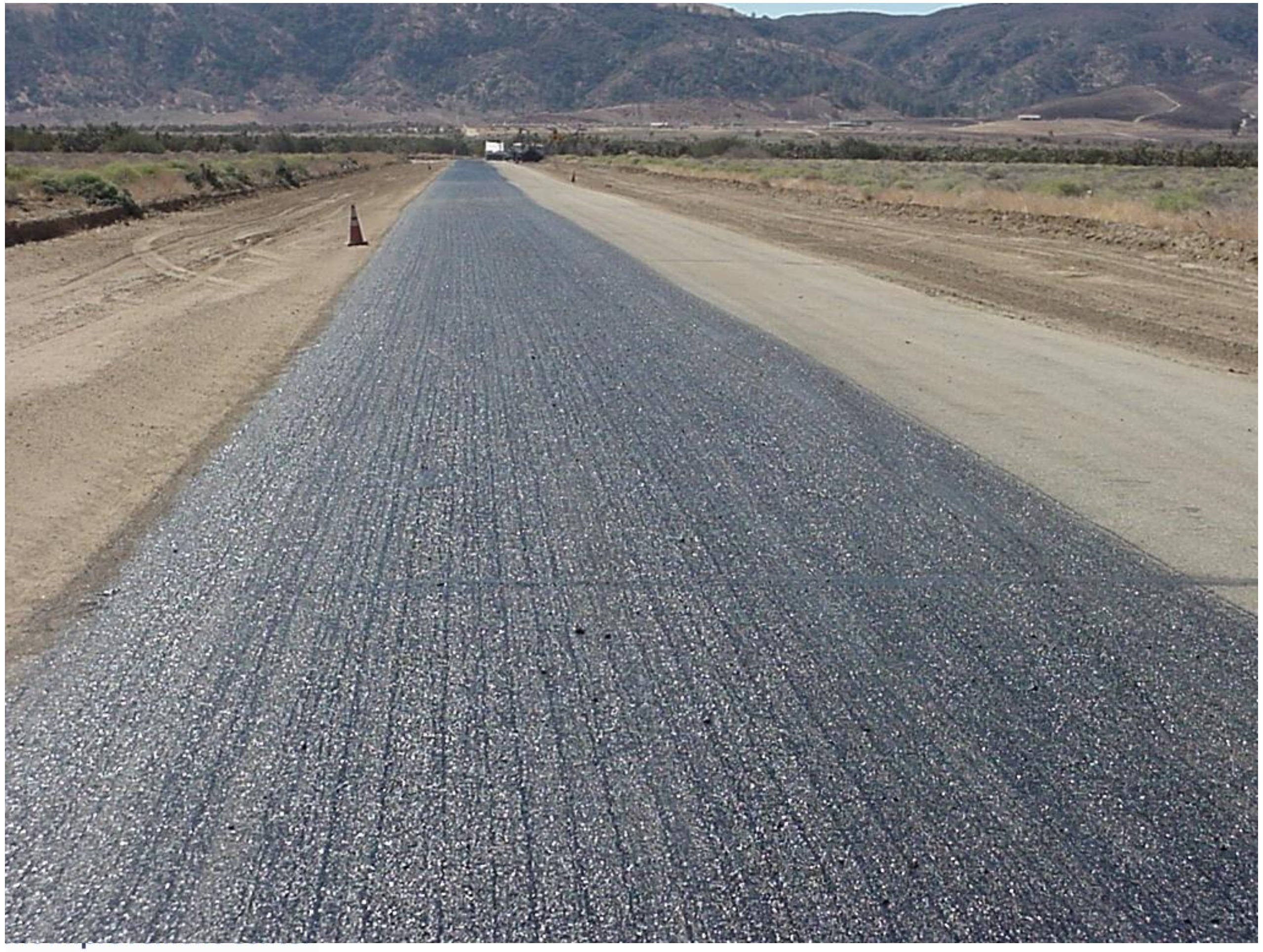
- Accelerated by lack of drainage.

Other Distresses: Delamination/Debonding

- Lack of bonding reduces overlay fatigue life by about 50%, even if no shoving
- Due to insufficient tack coat application
- Surface must be dry, clean, free of dust and residual millings
- Place between lifts, even if underlying lift is still hot
- Specify by residual amount
- Track-resistant materials available
- Spray pavers available

Tack Coat Application

- Proper tack coat application results in the pavement layers acting as a composite section
- Analogous to glue used in structural laminated beam
- Uniform application over the pavement surface, not streaked
- Ensure spray bar is pressurized and discharge cones overlap at least twice
- Encourage proper application by making a **separate Bid Item**.



Questions to ask when determining the next treatment:

- Are the cracks due to fatigue in the wheel paths (traffic), or aging of the entire surface (environment), or both?

- Is the network-level strategy in the PMS appropriate for the types of cracking?

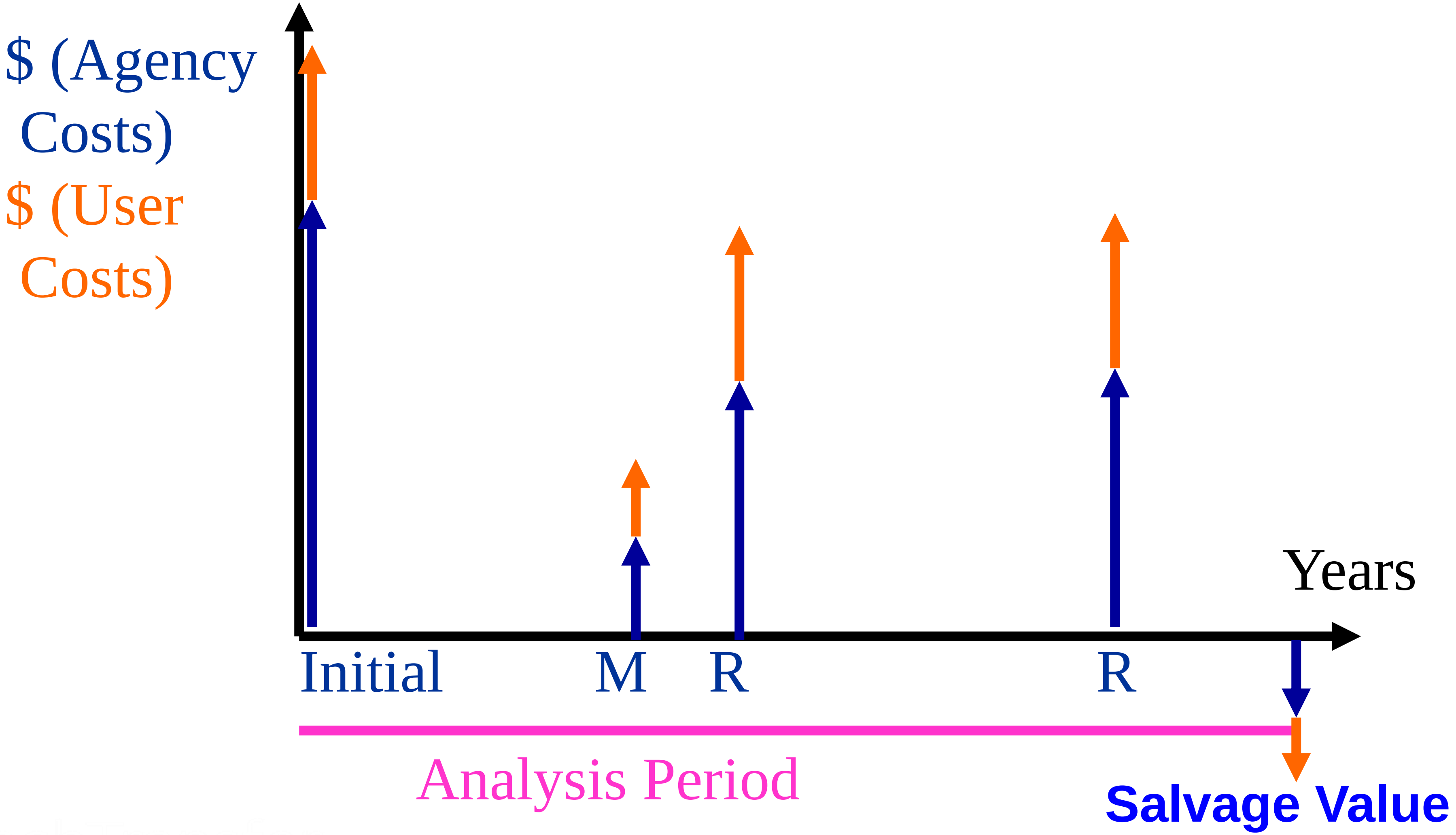
- Did the last project on the same route perform as expected? If not:
  - What's changed?
  - Is the structural section adequate?
  - Was a thorough project-level investigation, associated testing, and calculations performed?
  - Was the appropriate strategy selected?
  - What binder was used? Should a modified binder (polymer, asphalt-rubber) be used in the next project (particularly useful if inlay ("mill & fill")/overlaying cracking)?

Pavement "MRDI" Input for Selecting Next Treatment

- **M = Materials**: What is the structural section composed of? Subgrade, base material type and thickness, HMA/AC (gradation, binder type, thickness).
- **R = Review:** Completed projects at 3, 5, and 10-year milestones.
- **D = Desktop:** As-built plans, material testing records, traffic counts, traffic index calculations/projections, inspector records, change orders.
- **I = Investigation:** Was a project-level site investigation performed? Borings, Cores, Dynamic Cone Penetrometer (DCP), Falling Weight Deflectometer (FWD), Testing (SE, R-Value/CBR, PI).

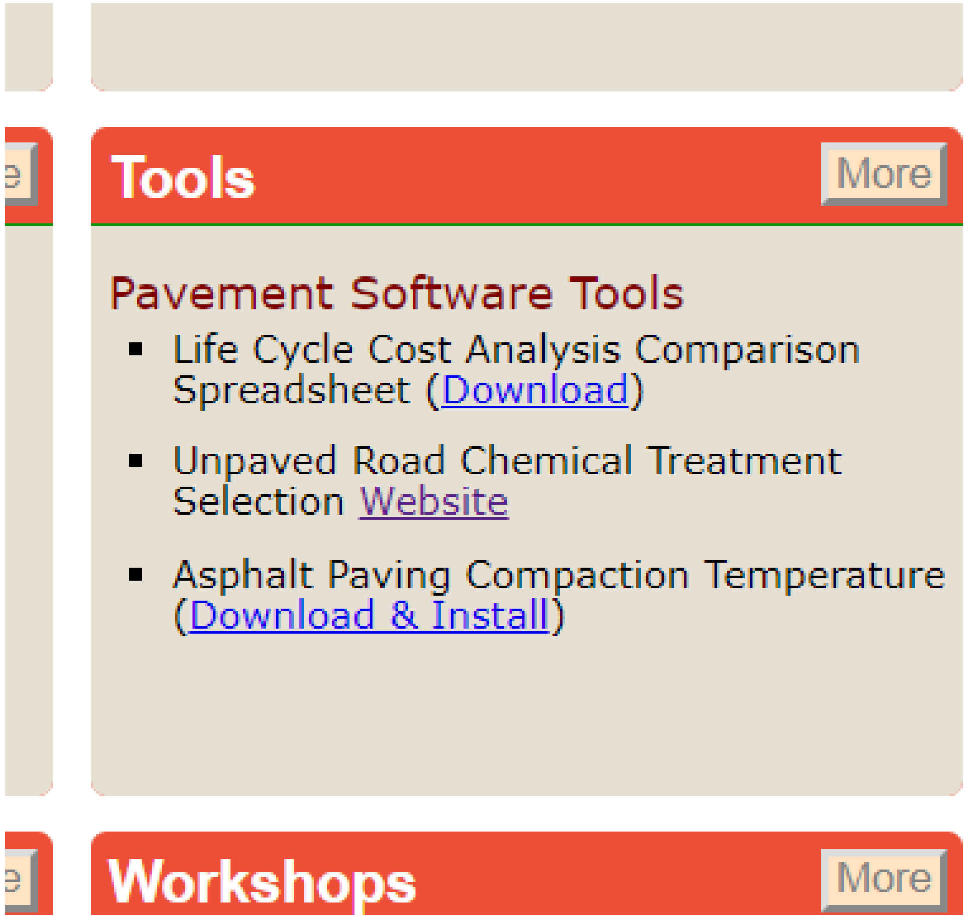
Life Cycle Cost Analysis

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



CCPIC LCCA Excel tool

- 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
- Download at CCPIC website



Effect of Compaction on Fatigue Life

- Use a quantitative (QC/QA) specification to measure compaction
- Write spec in terms of *in-place bulk density* and *theoretical maximum density* (TMD) and not *laboratory theoretical maximum density* (LTMD)
- Use cores or nuclear gauges calibrated for the specific mix/project to provide daily feedback to contractor and agency
- Apply payment reductions if they don't meet your specification, <u>and enforce those payment reductions</u>
- Future change to the Greenbook, Change No. 301SM, will incorporate CCPIC recommendations for asphalt compaction

General rule:

1% increase in constructed air-voids

= 10% reduction in fatigue life

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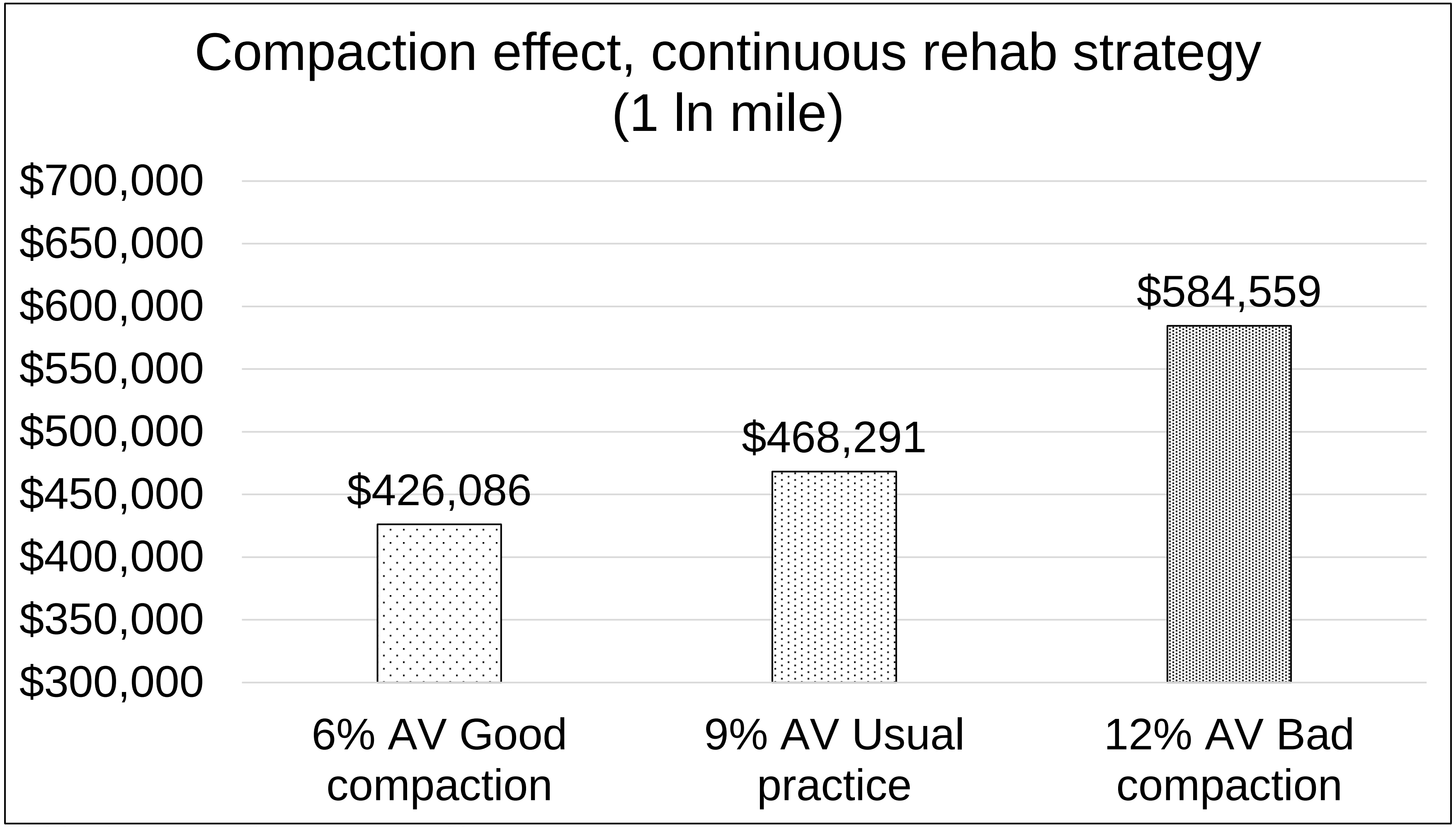
But what about?

- Won't this increase the bid cost for my asphalt?
- Isn't the cost of managing this specification high?
- Won't coring damage my new pavement?
- What can I do to help my contractors meet and exceed the specification and further increase the life of my overlays?

Life Cycle Cost Analysis: Effects of Asphalt Compaction



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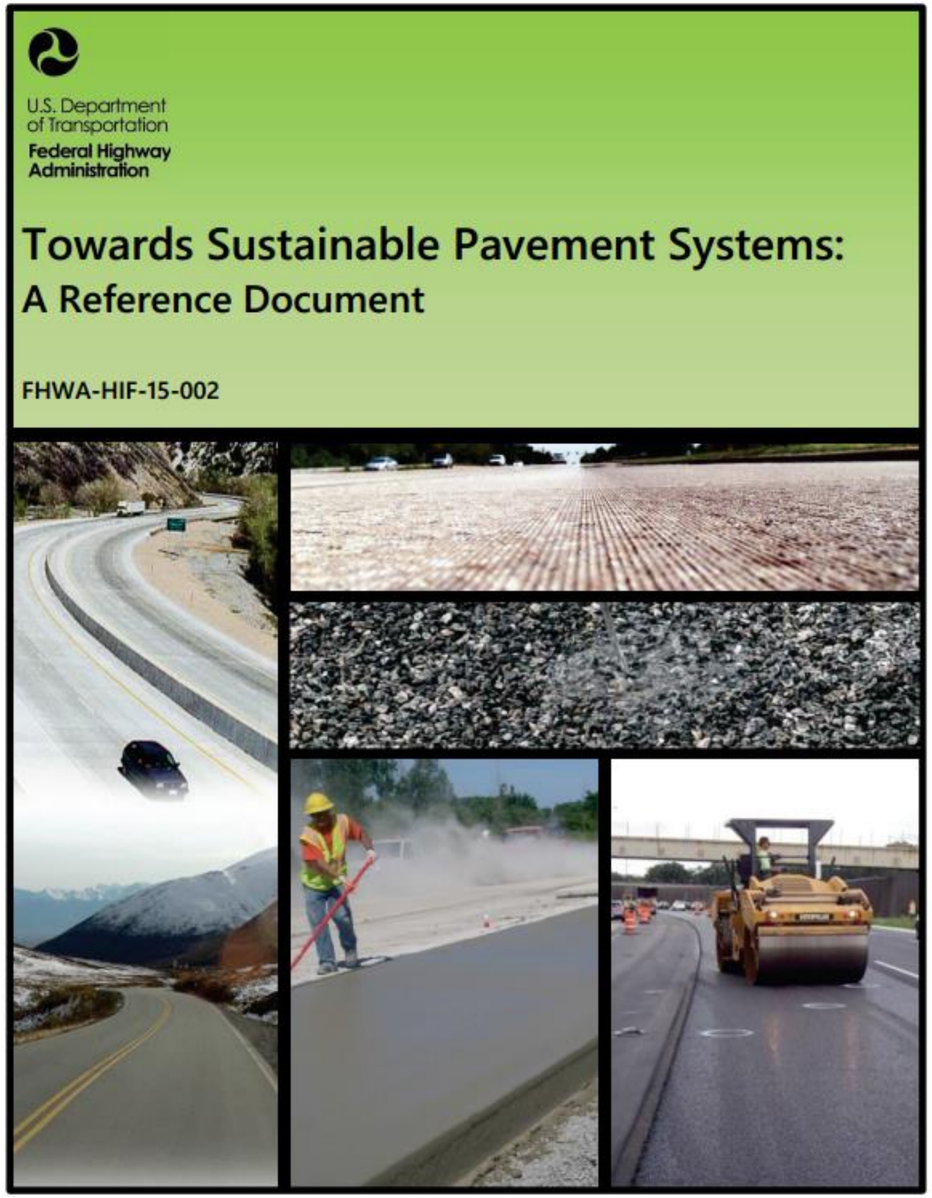
Main Takeaways

- Ability to make good engineering decisions regarding timing and type of treatment based only on PCI is limited; use the cracking data
- Life cycle cost analysis (LCCA) practical tool to determine most cost-effective strategies
  - Needs good performance estimates, agencies can use their own information
  - Focus on cracking, separated by:
    - Streets with heavy trucks/buses, wheelpath fatigue cracking and age related cracking, need rehabilitation eventually
    - Streets with no heavy vehicles, age related cracking only, can use only preservation treatments if timely
- Good asphalt compaction specification is most cost-effective change
  - 92% relative to theoretical maximum density not laboratory maximum density
  - Must be effectively enforced to work
- There are other things that can be done: see CCPIC training

So what can be done to make pavements more sustainable?

- FHWA Sustainable Pavements Task Group
  - More sustainable pavement reference document (2015)
  - Covers everything about pavement and sustainability
    - Cost
    - Environment
    - They usually go together
  - Tech briefs and webinars



References/Links

- University of California Pavement Research Center (UCPRC): www.ucprc.ucdavis.edu
- Maintenance Technical Advisory Guides: https://www.csuchico.edu/cp2c/library/caltrans-documents.shtml
- FHWA "Distress Identification Manual:" https://www.fhwa.dot.gov/publications/research/infrastructure/pavements/ltpp/13092/13092.pdf
- FHWA "Towards Sustainable Pavement Systems:" http://www.fhwa.dot.gov/pavement/sustainability/ref_doc.cfm

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