Pavements Sustainability 101

Tribal Transportation Program Webinar

Sustainable Pavement Systems

Manuel Sanchez

February 17, 2021

FHWA SUSTAINABLE PAVEMENTS PROGRAM

Program and Products

Vision and Mission

- To advance the knowledge and practice of designing, constructing, and maintaining more sustainable pavement through:
  - Stakeholder engagement
  - Education
  - Development of guidance and tools

FHWA Sustainability Ambassadors

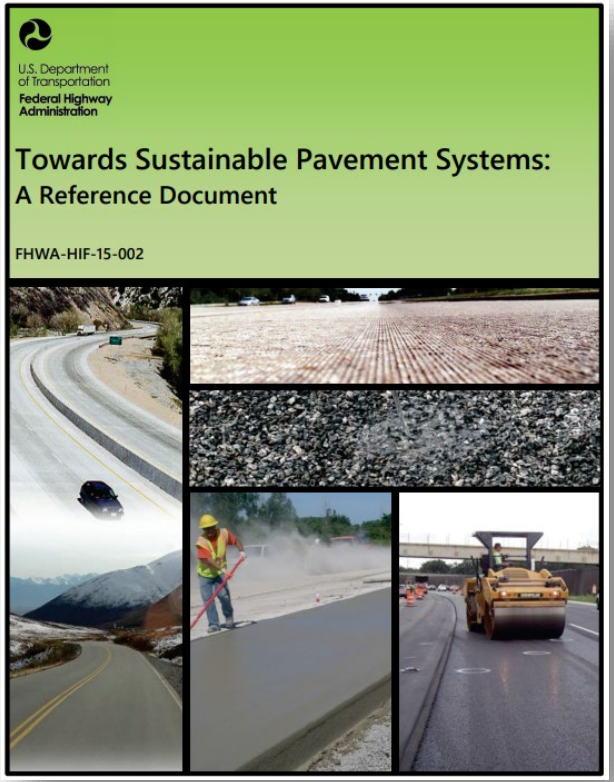
A group of FHWA employees from different disciplines.

Sustainability Ambassadors Goal

To expand the knowledge and outreach within their field that complements the Sustainable Pavements Program.

Key Takeaways

- Definition and characteristics of pavement sustainability
- Benefits of moving toward sustainable pavement systems
- Current sustainability practices
- Emerging trends and technologies
- Tools to measure and quantify sustainability



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

SUSTAINABLE PAVEMENTS AND THE PAVEMENT LIFE CYCLE

Definition: Sustainable Pavements

1. Achieve the engineering goals.
2. Preserve and (ideally) restore surrounding ecosystems.
3. Use financial, human, and environmental resources wisely.
4. Meet basic human needs such as health, safety, equity, employment, comfort, and happiness.

Opportunities for Improving Sustainability Exist Throughout the Pavement Life Cycle

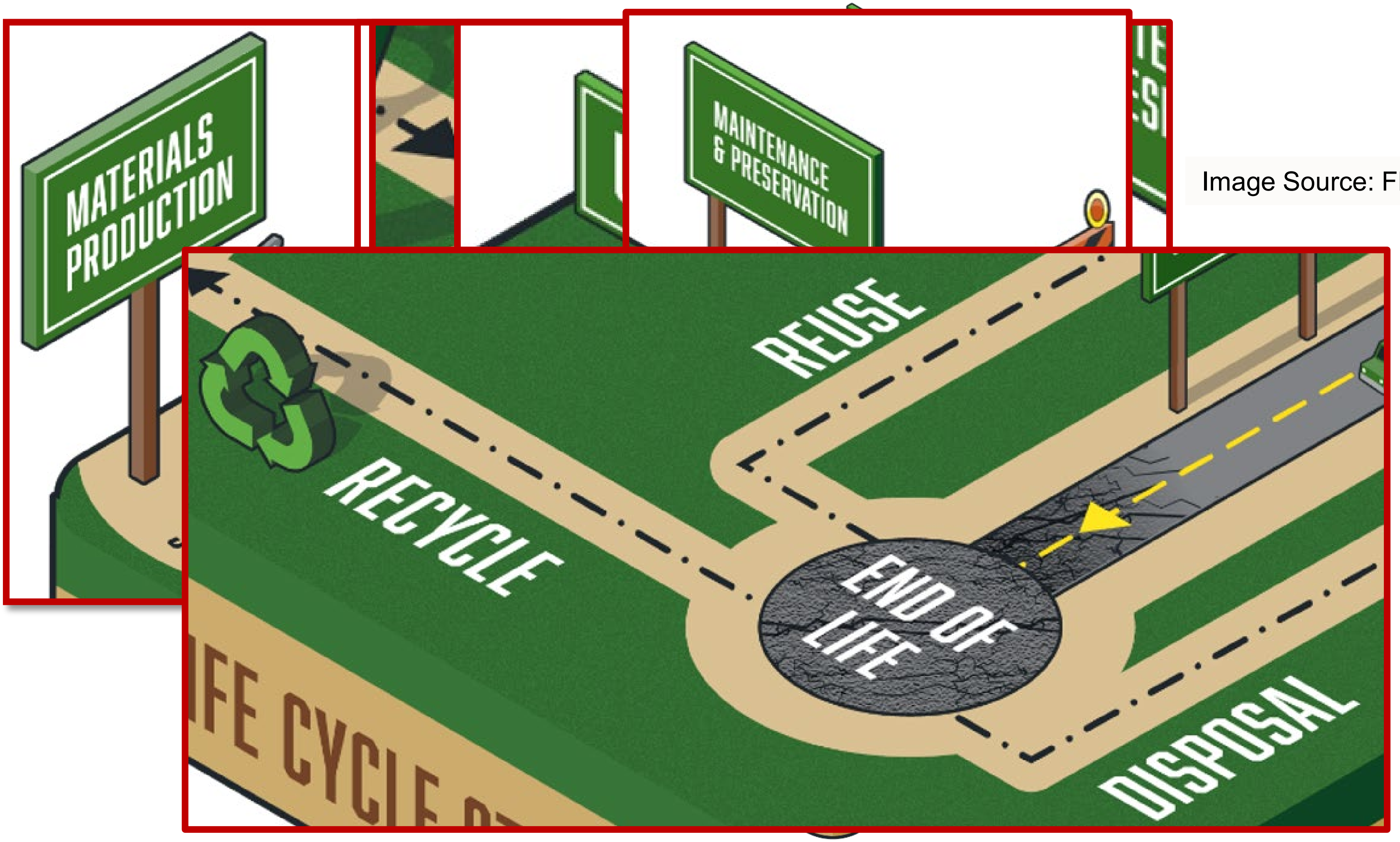


Image Source: FHWA/APTech

WHY SHOULD WE CARE ABOUT PAVEMENT SUSTAINABILITY?

Benefits of Being More Sustainable

- Reduced pavement life-cycle costs

- Reduced energy
- Reduced noise
- Improved air quality

- Improved safety
- Improved ride
- Conservation of resources

HOW DO WE CONSIDER SUSTAINABILITY IN DESIGN?

Characteristics of Sustainability

- Sustainability is a continuum
- Sustainability is not an add-on value
- Sustainability requires innovation
- Sustainability is context sensitive

Sustainability = Good Engineering Practice

Example Sustainability Priorities/Values

Access	Finances
Healthy Life	Cost-Benefit
Safety	Clean Air
Culture/History	Clean Water
Aesthetics	Clean Land
Education	Ecological Res.
Equality	Water Res.
Fair Wages	Consumption
Governance	Renewables
Transition	Emissions
Livability	Employment

Sustainability…

- Considers **all** life cycle stages
- Looks for continuous and ongoing improvements
- Prioritizes and operationalizes values through a conscious effort
- **IS NOT** an add-on value to a system

Trade-Off Considerations

- Improving one outcome may compromise another
- Consideration of **Opportunity Costs**
- Priorities/values of the organization/project
  - Which sustainability components are particularly valued?
  - How do we prioritizes these values?
  - How do we operationalize these values?
- Risk
  - What risks do we face?
  - How much risk is acceptable?

SUMMARY

Key Takeaways

- "Sustainable" in the context of pavements refers to system characteristics that encompass a pavement's ability to:
  - Achieve engineering goals
  - Preserve ecosystems
  - Use resources judiciously
  - Meet basic human needs
- Consider the entire pavement life-cycle

Key Takeaways

- Sustainability is a continuum
- Sustainability is not an add-on value
- Sustainability requires innovation
- Sustainability is context sensitive
- Sustainability can be measured
- Sustainability involves trade-offs
- The FHWA's *Sustainable Pavements Program* provides many resources to help agencies

How do we Measure Sustainability?

Tribal Transportation Program Webinar
Sustainable Pavement Systems

Monica Jurado
February 17, 2021

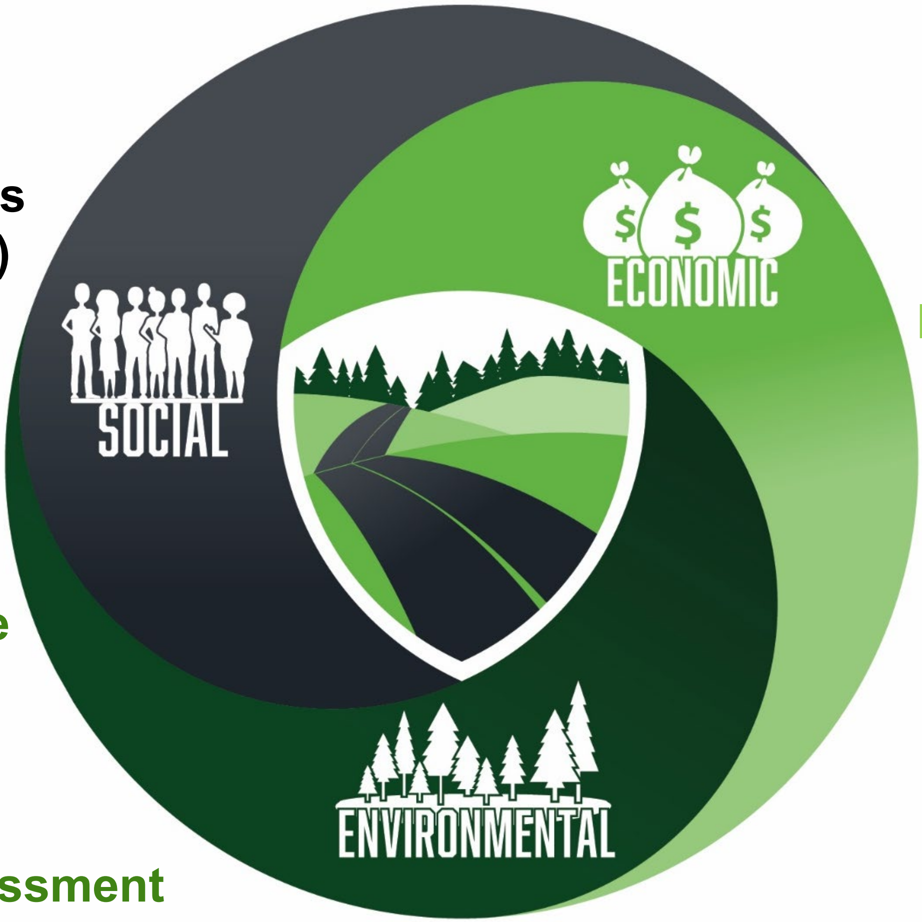
HOW DO WE MEASURE PAVEMENT SUSTAINABILITY?

Balance of the Triple Bottom Line

Sustainability Rating Systems (e.g., INVEST)

Performance Testing

Life-Cycle Cost Analysis (LCCA)



Performance Testing

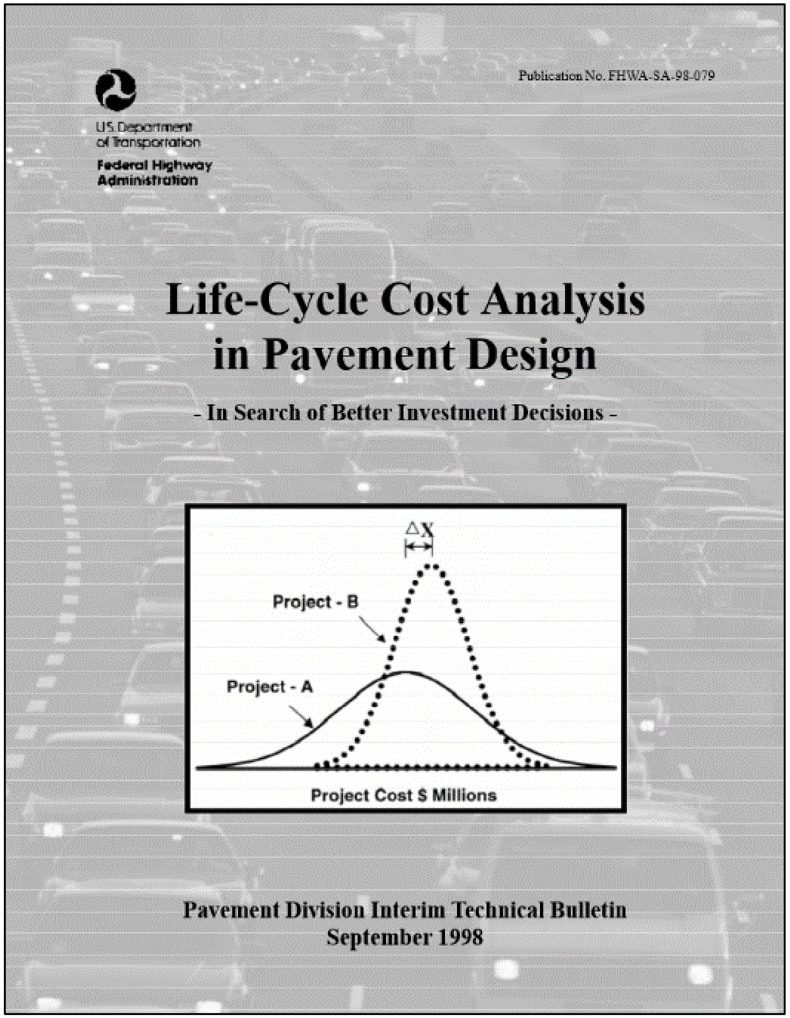
Life-Cycle Assessment (LCA)

Image Source: FHWA/APTech

Performance Tests

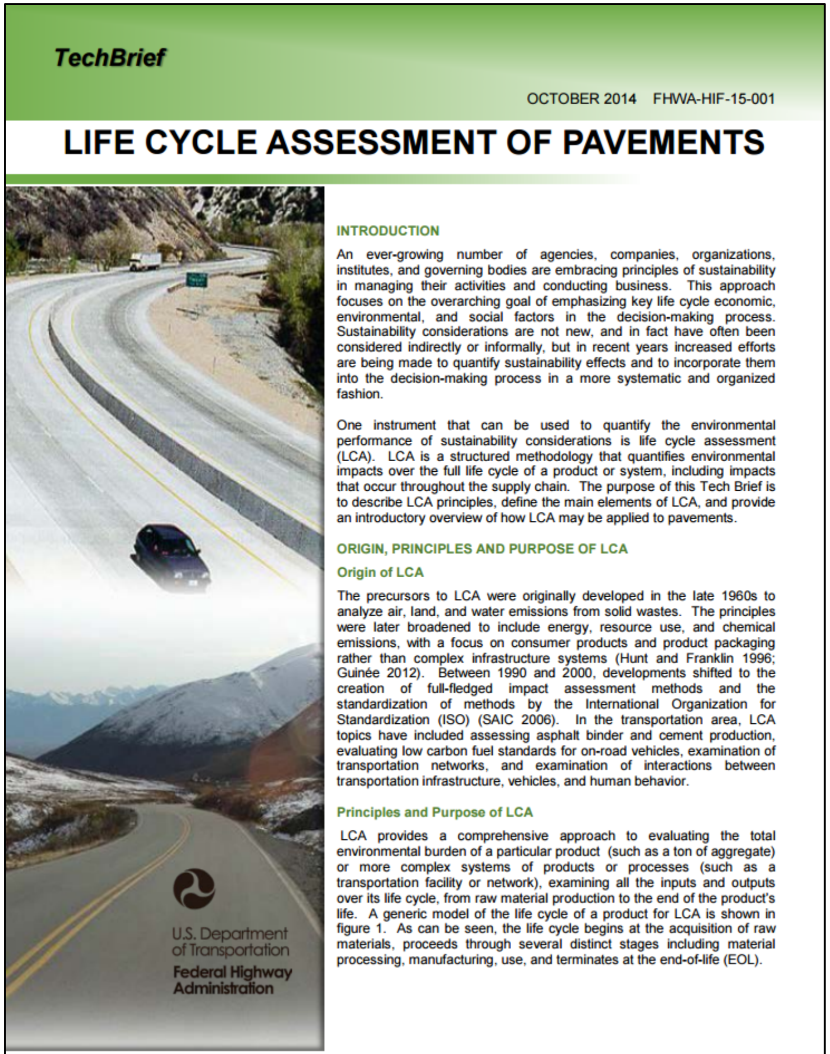
Photo credit: S. Muench

Life-Cycle Cost Analysis



Title:	**Life-Cycle Cost Analysis in Pavement Design – Interim Technical Bulletin**
Authors:	Walls and Smith (for FHWA)
Published:	1998
Description:	Recommends procedures for conducting LCCA of pavements. Set's standard for inclusion of user costs (WZ only) and probabilistic analysis.
Where:	USDOT and various other websites • http://isddc.dot.gov/OLPFiles/FHWA/013017.pdf

Life-Cycle Assessment



TechBrief

OCTOBER 2014 FHWA-HIF-15-001

LIFE CYCLE ASSESSMENT OF PAVEMENTS

INTRODUCTION

An ever-growing number of agencies, companies, organizations, institutes, and governing bodies are embracing principles of sustainability in managing their activities and conducting business. This approach focuses on the overarching goal of emphasizing key life cycle economic, environmental, and social factors in the decision-making process. Sustainability considerations are not new, and in fact have often been considered indirectly or informally, but in recent years increased efforts are being made to quantify sustainability effects and to incorporate them into the decision-making process in a more systematic and organized fashion.

One instrument that can be used to quantify the environmental performance of sustainability considerations is life cycle assessment (LCA). LCA is a structured methodology that quantifies environmental impacts over the full life cycle of a product or system, including impacts that occur throughout the supply chain. The purpose of this Tech Brief is to describe LCA principles, define the main elements of LCA, and provide an introductory overview of how LCA may be applied to pavements.

ORIGIN, PRINCIPLES AND PURPOSE OF LCA

Origin of LCA

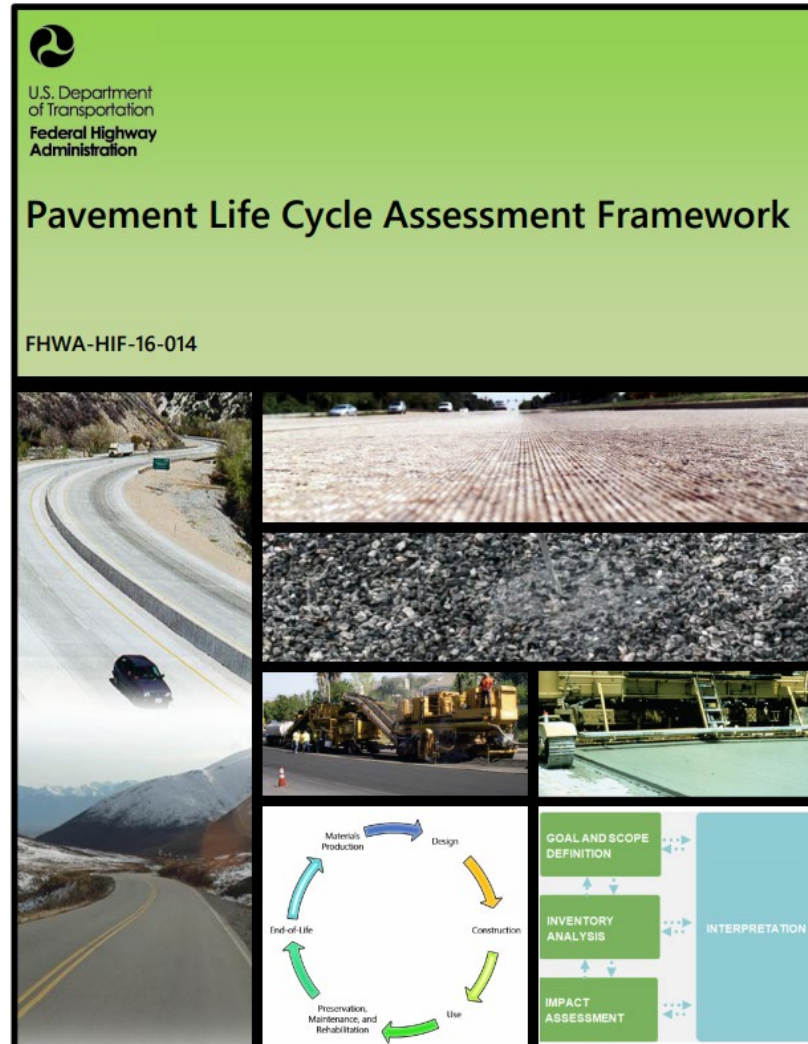
The precursors to LCA were originally developed in the late 1960s to analyze air, land, and water emissions from solid wastes. The principles were later broadened to include energy, resource use, and chemical emissions, with a focus on consumer products and product packaging rather than complex infrastructure systems (Hunt and Franklin 1996; Guinée 2012). Between 1990 and 2000, developments shifted to the creation of full-fledged impact assessment methods and the standardization of methods by the International Organization for Standardization (ISO) (SAIC 2006). In the transportation area, LCA topics have included assessing asphalt binder and cement production, evaluating low carbon fuel standards for on-road vehicles, examination of transportation networks, and examination of interactions between transportation infrastructure, vehicles, and human behavior.

Principles and Purpose of LCA

LCA provides a comprehensive approach to evaluating the total environmental burden of a particular product (such as a ton of aggregate) or more complex systems of products or processes (such as a transportation facility or network), examining all the inputs and outputs over its life cycle, from raw material production to the end of the product's life. A generic model of the life cycle of a product for LCA is shown in figure 1. As can be seen, the life cycle begins at the acquisition of raw materials, proceeds through several distinct stages including material processing, manufacturing, use, and terminates at the end-of-life (EOL).

U.S. Department of Transportation
Federal Highway Administration

https://www.fhwa.dot.gov/pavement/pub_details.cfm?id=935



https://www.fhwa.dot.gov/pavement/pub_details.cfm?id=998

Infrastructure Sustainability Rating Systems Examples

- INVEST
- Greenroads
- Envision
- LEED for Neighborhood Development

https://www.sustainablehighways.org/

Reasons to Measure Sustainability

- Achieving sustainability and performance goals
- Satisfying accounting mandates
- Providing decision support
- Improving agency processes
- Improving public image

What Can I Learn from This Presentation?

- What is life-cycle cost analysis (LCCA) and how can it help highway agencies?
- What are the steps in the pavement LCCA process?
- What are some tools available to conduct LCCA?
- Where can I find more information on LCCA?

LCCA

WHAT IS LIFE-CYCLE COST ANALYSIS (LCCA)?

What Is LCCA?

- Analytical tool to provide cost comparisons between two or more competing alternatives on a project
- Alternatives are assumed to produce equivalent benefits
- For pavements, LCCA considers
  - Direct agency costs
  - User costs

What Are the Benefits of Conducting LCCA?

- Reduced pavement life-cycle costs and impact to users

- Reduced energy
- Reduced noise
- Improved air quality

- Improved safety
- Improved ride
- Conservation of resources

Primary LCCA Benefit

LCCA can be used with Life Cycle Assessment (LCA) and Sustainability Rating Systems to improve environmental and social performance

How Can LCCA Help Highway Agencies?

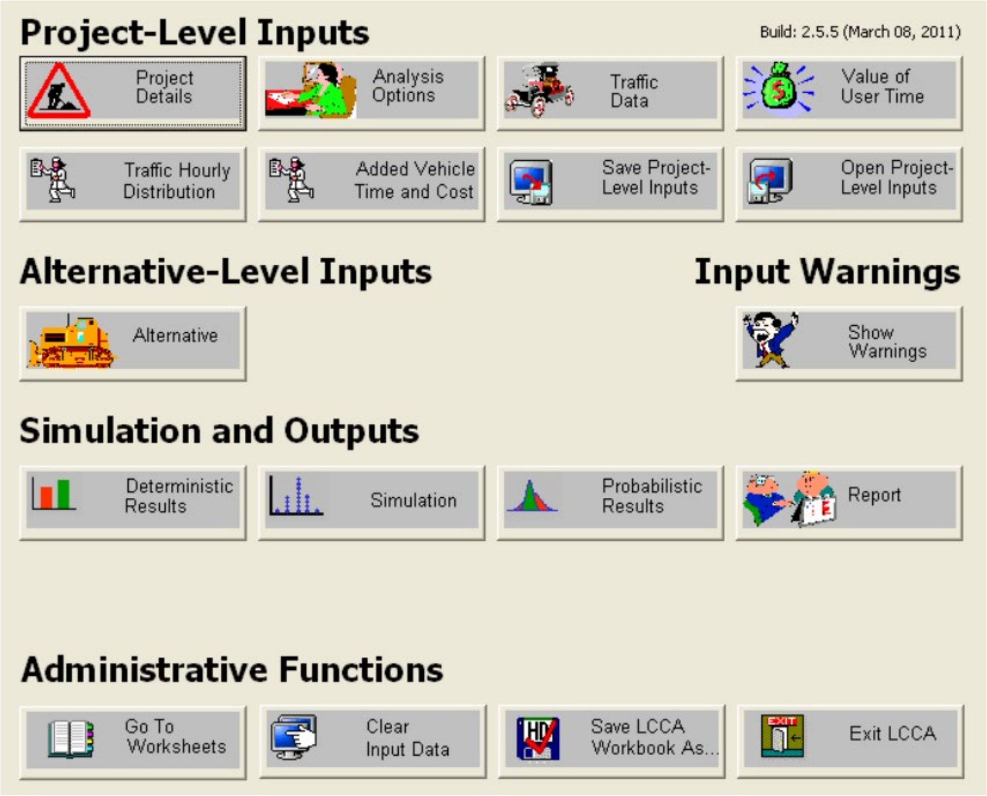
- Comparing materials for pavements
- Comparing maintenance, preservation, and rehabilitation strategies
- Comparing construction work zone effects
- Comparing alternative bids

- LCCA helps identify opportunities to reduce agency and user costs throughout the pavement life cycle
- LCCA helps inform and guide decision-making for policy, planning, or design

WHAT ARE SOME TOOLS AVAILABLE TO CONDUCT LCCA?

FHWA *RealCost* Software

- Widely accepted and adopted LCCA tool for pavements (in the U.S.)



https://www.fhwa.dot.gov/infrastructure/asstmgmt/lccasoft.cfm

WHERE CAN I FIND MORE INFORMATION ON LCCA?

Available Resources and Tools

- FHWA LCCA Technical Bulletin
- FHWA RealCost Tool
- FHWA LCCA Primer
- FHWA LCCA Factsheet
- FHWA LCCA Webpage

SUMMARY

Key Takeaways

- Economic impact is an important component of pavement sustainability
- LCCA is a well-established process for assessing and comparing the monetarily quantifiable aspects of competing pavement design and rehab alternatives
- LCCA should be used with appropriate inputs
- *RealCost* is a pavement LCCA tool available.

Maintenance and Preservation Treatments to Improve Sustainability

Tribal Transportation Program Webinar
Sustainable Pavement Systems

Migdalia Carrion
February 17, 2021

What Can I Learn From This Presentation?

- What is pavement preservation?
- What are the impacts of preservation on pavement sustainability?
- What are some common pavement preservation techniques for asphalt- and concrete-surface pavements?
- What are some future opportunities?

Opportunities for Improving Sustainability Exist Throughout the Pavement Life Cycle

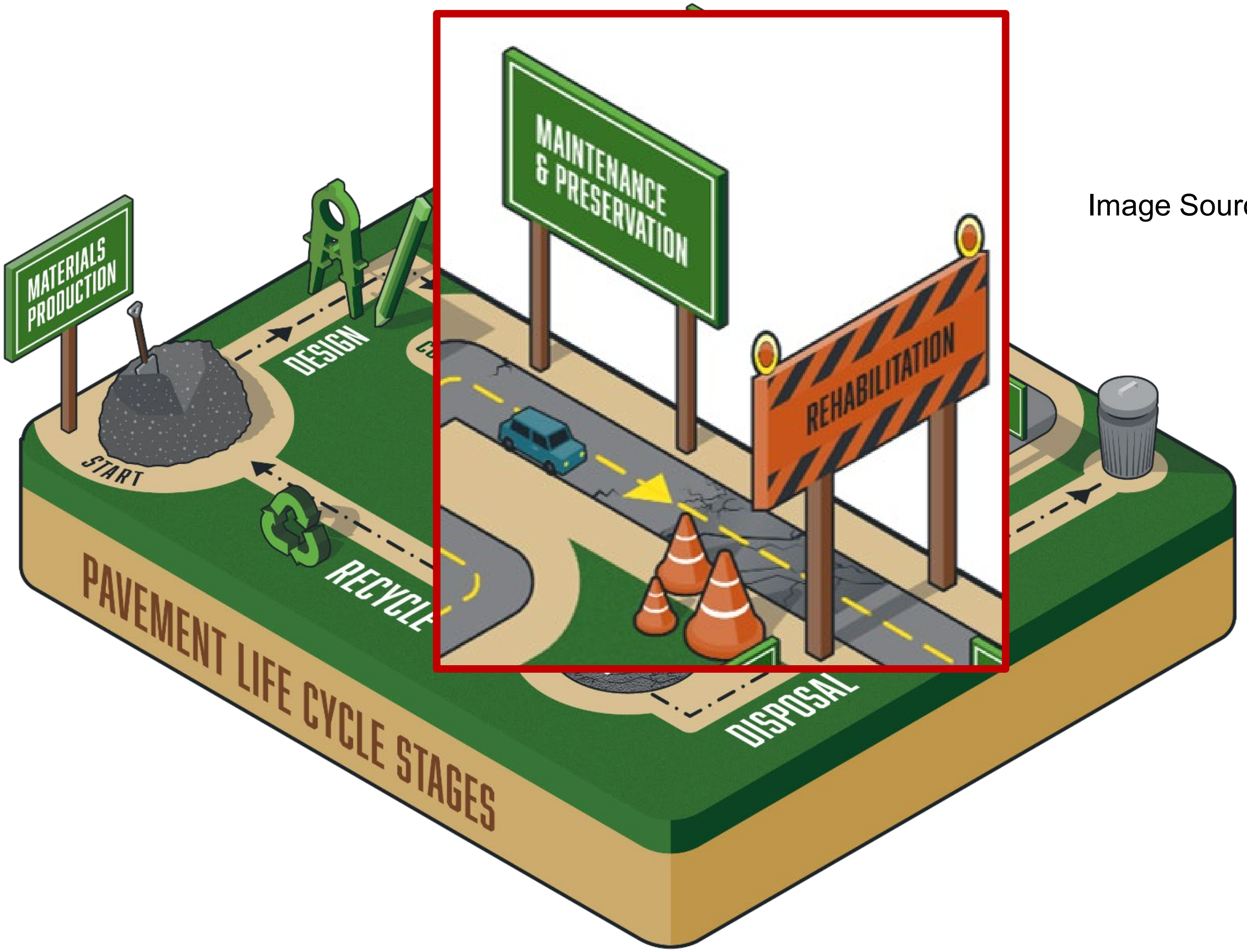


Image Source: FHWA/APTech

WHAT IS PAVEMENT PRESERVATION?

What is Pavement Preservation?

Images Source: APTech

- Keeping good roads in good condition
- Employs maintenance, preventive maintenance, and minor rehabilitation treatments
  - Typically low-cost, low-environmental-impact activities

Impact of Pavement Preservation

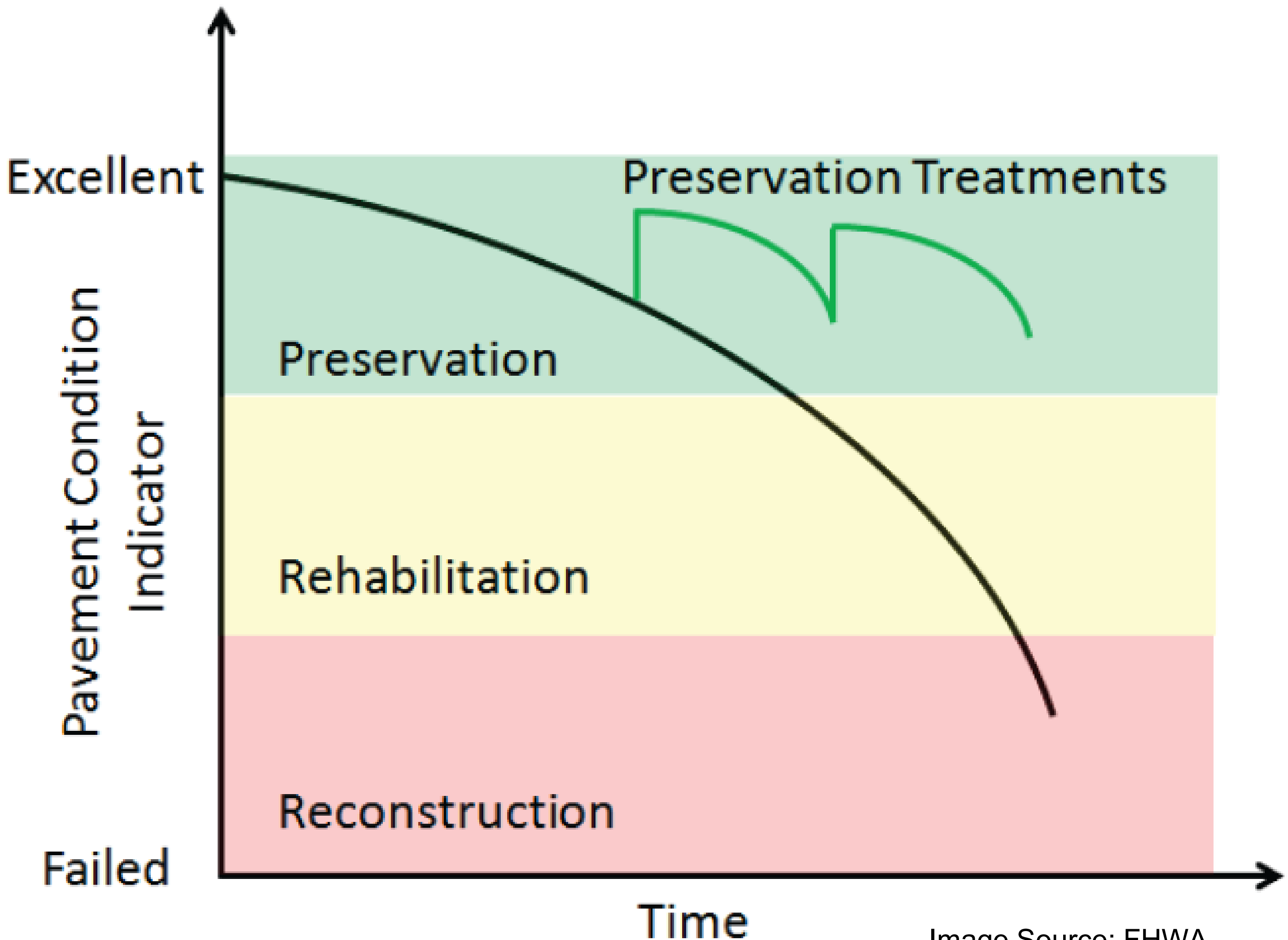


Image Source: FHWA

Selection of Preservation Techniques

- **Consider:**
  - Pavement type
  - Type and extent of distress
  - Climate
  - Cost
  - Expected life
  - Functional requirements

- **Other factors:**
  - Traffic management
  - Traffic volumes
  - Contractor and material availability

WHAT ARE THE IMPACTS OF PRESERVATION ON PAVEMENT SUSTAINABILITY?

Preservation Sustainability Benefits

- Conserves energy and virgin materials
- Restores/maintains functionality
  - Improves safety
  - Reduces noise
  - Improves smoothness and fuel efficiency
  - Enhanced aesthetics
- Extends pavement life
- Impacts are context-sensitive

Preservation on Low-Volume Roads

- Use-stage impacts less important
  - Agency impacts dominate decision making
  - Minimize treatment application and the amount of material used for each treatment
  - Optimize treatment selection and timing to avoid major structural damage

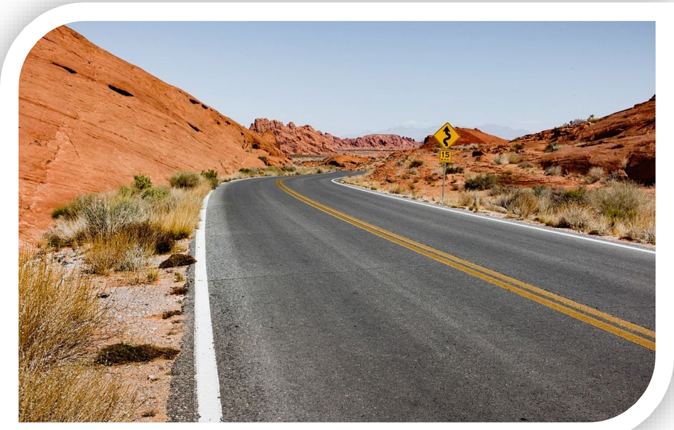


Image Source: Pixabay

Preservation on High-Volume Roads

- Use-stage impacts more important
  - Impacts of preservation activities minor in comparison
  - Vehicle operations can dominate
- Agency and user impacts/costs must be considered

Image Source: Pixabay

Agency Impacts vs. User Impacts

- Agencies typically focused on minimizing life-cycle costs
  - Appropriate for low-volume facilities
- Agencies need to consider broader sustainability impact of their choices for high-volume roads
  - Keep smooth pavements smooth, safe pavements safe, and quiet pavements quiet

WHAT ARE SOME COMMON PRESERVATION TREATMENTS FOR ASPHALT-SURFACED PAVEMENTS?

Crack Filling/Sealing

- Placement of adhesive material into or over asphalt pavement cracks
- Extends pavement life by keeping pavement sealed against moisture infiltration

Image Source: FHWA

Patching

- Used to treat localized distresses
  - Partial-depth patches for surface defects
  - Full-depth patches to address structural issues
- Restores structural integrity and ride quality

Image Source: FHWA

Fog Seal/Rejuvenator

- Addition of fresh asphalt binder to existing asphalt surface
  - Seals pavement surface
  - Prevents or slows oxidation
  - Prevents further loss of aggregates from existing pavement

Image Source: FHWA

Chip Seal

- Asphalt binder applied to pavement surface followed by aggregate chips rolled into binder
  - Seals pavement surface
  - Extends service life
  - Improve aesthetics

Image Source: FHWA

Slurry Seal

- Mixture of well-graded aggregate and asphalt emulsion spread over pavement surface
  - Seals pavement service
  - Extends service life
  - Improves friction
  - Improves aesthetics

Image Source: FHWA

Microsurfacing

- Mixture of well-graded aggregate, mineral filler, and polymer-modified asphalt emulsion spread over pavement surface
  - Seals pavement service
  - Extends service life
  - Improves friction
  - Improves aesthetics

Image Source: FHWA

Ultra-Thin and Thin Asphalt Overlays

- Ultra-Thin: 0.625 to 0.75 inches
- Thin: 0.75 to 1.50 inches
- Addresses minor surface distress
- Restores friction
- Improves ride quality
- Improves aesthetics

Image Source: FHWA

Hot In-Place Recycling (HIR)

- Binder softened and loosened, mixed with recycled aggregates/rejuvenators/virgin asphalt before placement and compaction
- Limited to top 2 inches
- Addresses minor surface defects
- Improves ride quality
- Improves aesthetics

Cold In-Place Recycling (CIR)

- Cold milling; sizing reclaimed asphalt pavement (RAP); mixing RAP with asphalt emulsion, recycling additives, and new aggregate to produce cold mix
- Addresses surface distresses, fixes rutting
- Corrects minor profile deficiencies

Ultra-Thin Bonded Wearing Course

- Gap-graded or open-graded polymer or rubber-modified asphalt layer placed on thick tack coat
  - Seals pavement surface
  - Addresses surface defects
  - Restores friction
  - Improve ride quality
  - Improves aesthetics

Bonded Concrete Overlays

- Placement of thin concrete layer (2 to 6 inches) onto a cold-milled asphalt pavement
  - Short panel dimensions
  - May include fibers
- Extends service life
- Restores friction and eliminates profile issues
- Improves aesthetics

Image Source: FHWA

Relative Sustainability Impacts

Treatment	Relative Treatment Life	Relative Initial Cost	Relative Environmental Impact	Societal Impact
Crack Filling and Sealing	✓	$	Low	Reduced traffic delays, less pleasing aesthetics, potentially rough
Asphalt Patching	✓✓	$	Variable	Reduced traffic delays, negative impact on ride quality and noise
Fog Seal	✓	$	Med	Reduced traffic delays, improves aesthetics
Chip Seal	✓✓	$$	Med	Increased safety (friction), reduced traffic delays, rough surface, noise
Slurry Seal	✓✓	$$	Med	Increased safety (friction), reduced traffic delays, improved aesthetics

Relative Sustainability Impacts

Treatment	Relative Treatment Life	Relative Initial Cost	Relative Environmental Impact	Societal Impact
Microsurfacing	✓✓✓	$$	Med to High	Increased safety (friction), reduced traffic delays, improved aesthetics
Ultra-thin HMA Overlay	✓✓✓✓	$$$	High	Improved ride quality, fuel savings, increased safety (friction, splash/spray), improved aesthetics
Hot In-Place Recycling	✓✓✓	$$$	Med to High	
Cold In-Place Recycling	✓✓✓	$$$	Med to High	
Bonded Concrete Overlay	✓✓✓✓	$$$$	Med	Improved safety (friction and drainage), improved ride quality and aesthetics

ASPHALT PAVEMENT PRESERVATION: WHAT ARE SOME FUTURE OPPORTUNITIES?

Future Opportunities

- Improved treatments that last longer and use less materials
- Optimization of treatment selection using pavement management systems
- Improvements in paving machines: tack coat placement immediately ahead of hot-mix laydown
- Improved compaction
- Improvements in construction quality

WHAT ARE SOME COMMON PRESERVATION TREATMENTS FOR CONCRETE-SURFACED PAVEMENTS?

Joint Resealing/Crack Sealing

- Preparation of joints/crack and installation of new sealant material
- Extends pavement life by keeping pavement sealed against moisture infiltration

Image Source: FHWA

Diamond Grinding

- Removal of thin layer of material (0.12 to 0.25 inches) from concrete surface
- Addresses faulting and other surface irregularities
- Provides riding surface that is as good or better than original pavement

Image Source: ACPA

Bonded Concrete Overlays

- Placement of relatively thin concrete layer (2 to 4 inches) over existing pavement after deteriorated areas are repaired
- Improves friction and ride quality
- Reduces noise emissions
- Improves aesthetics

Image Source: FHWA

Diamond Grooving

- Cutting of narrow, discrete grooves on concrete pavement surface
- Improves safety
  - Reduces hydroplaning
  - Reduces splash/spray
- Reduces noise

Image Source: APTech

Slab Stabilization/Slab Jacking

- Slab Stabilization: Fill voids under concrete pavement and restores support
- Slab Jacking: Injection of cement grout or expansive polyurethane material to restore settled slab to original profile
- Restores slab support and reduces deflections

Partial-Depth Repairs

- Used to address distresses limited to top one-third/one-half of slab
- Restores ride quality and structural integrity of localized areas

Image Source: FHWA

Full-Depth Repairs

- Used to address deteriorated joints or entire slabs
- Extends through entire thickness of existing slab
- Restores ride quality and structural integrity

Image Source: APTech

Dowel Bar Retrofit

- Placement of dowel bars across joints or cracks with poor load transfer
  - Provides/restores load transfer
  - Reduces deflections

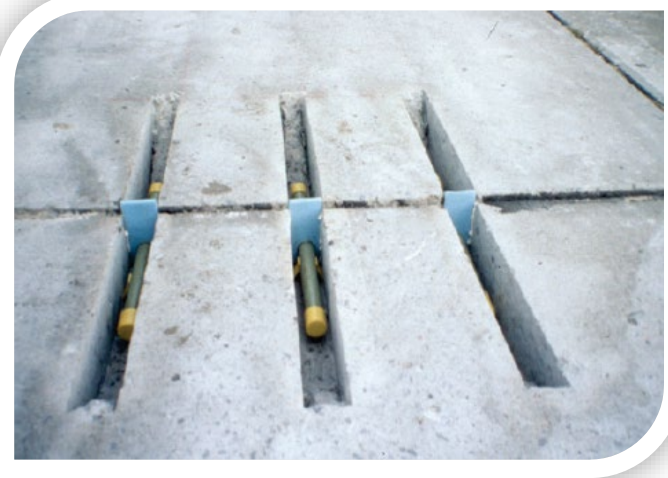


Image Source: FHWA

Cross Stitching

- Technique to maintain load transfer across non-working cracks
- Keeps crack tight
- Alternative to full-depth repairs if implemented properly

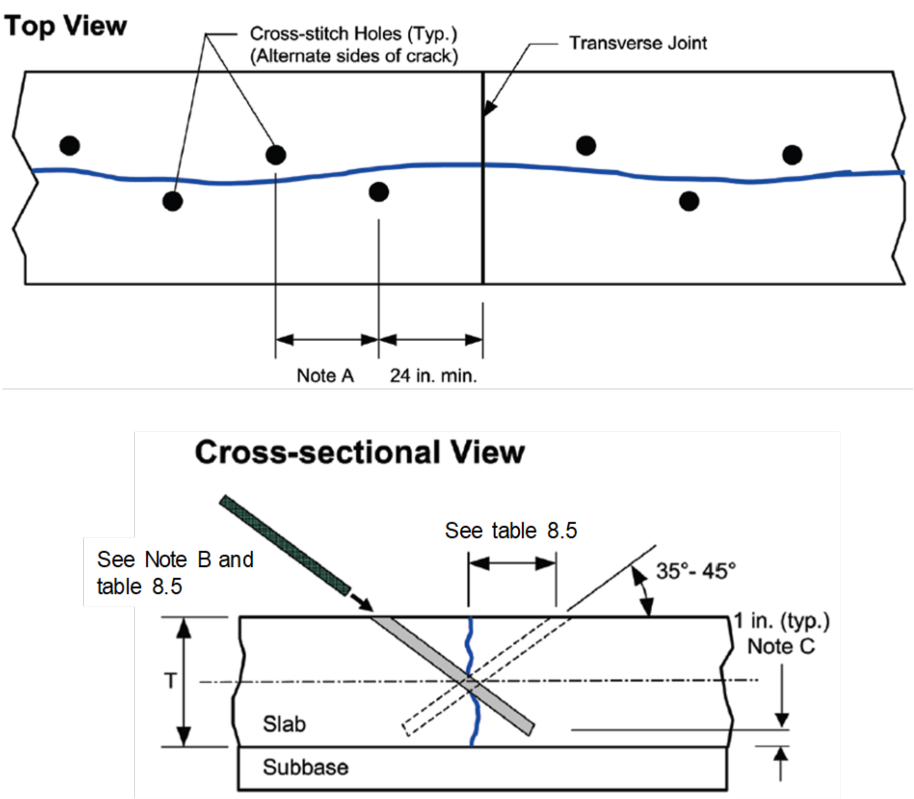


Image Source: ACPA

Relative Sustainability Impacts

Treatment	Relative Treatment Life	Relative Initial Cost	Relative Environmental Impact	Societal Impact
Joint Resealing	✓	$	Low	Reduced traffic delays, less pleasing aesthetics, potentially rough
Slab Stabilization/ Slab Jacking	✓✓	$$$	Low to Medium	Improves ride quality when combined with other treatments
Diamond Grinding	✓✓✓	$$	Med to High	Increases safety (friction), reduces tire-pavement noise
Diamond Grooving	✓✓✓	$$	Low to Med	Increases safety, reduces tire-pavement noise
Partial-Depth Repair	✓✓	$$$	Variable	Improved ride quality, rapid-set materials can reduce traffic delays

Relative Sustainability Impacts

Treatment	Relative Treatment Life	Relative Initial Cost	Relative Environmental Impact	Societal Impact
Full-Depth Repair	✓✓✓	$$$$	Med to High	Precast panels can reduce traffic delays, potential aesthetic issues
Dowel Bar Retrofit	✓✓✓✓	$$$	Variable	Improves ride quality (controls faulting), aesthetics negatively affected
Cross Stitching	✓✓	$$$	Low	Improves long-term performance
Retrofitted Edge Drains	✓✓✓	$$$$	Variable	Improves long-term performance
Bonded Concrete Overlay	✓✓✓✓	$$$	Medium	Improved friction, ride quality, drainage, and aesthetics

CONCRETE PAVEMENT PRESERVATION: WHAT ARE SOME FUTURE OPPORTUNITIES?

Future Opportunities

- Improved treatments that last longer and use less materials
- Optimization of treatment selection using pavement management systems
- Use of precast solutions
- Alternative repair materials

SUMMARY

Key Takeaways

- Keep good pavements good, smooth pavements smooth, quiet pavements quiet, and safe pavements safe
- Multiple treatment options exist for asphalt and concrete pavements
- Relationship between pavement preservation and sustainability is context sensitive
- Consider entire life cycle when making treatment selection decisions

Example Products

- Guide Documents:
  - *Towards Sustainable Pavement Systems*
  - *Pavement Life Cycle Assessment Framework*
- Tech Briefs on following topics:
  - *Pavement Sustainability*
  - *Life Cycle Assessment*
  - *Improving Resiliency of Pavement Systems*
  - *Strategies for Improving Sustainability of Asphalt/Concrete Pavements*
- Webinar series on pavement sustainability
- *Sustainable Pavements Program Road Map*

To Learn More:

	WEBINAR EVENT	WHAT WILL YOU LEARN?	DATE & TIME
1	Pavement Sustainability Basics	Sustainability concepts and assessment tools	October 17, 2019 2:30–3:30 PM ET
2	Sustainable Pavement Materials	Sustainability implications of aggregate, asphalt, and concrete pavement materials	November 21, 2019 2:30–3:30 PM ET
3	Sustainable Design Approaches	Design considerations related to sustainability, general and specific design strategies, emerging trends	December 19, 2019 2:30–3:30 PM ET
4	Sustainable Pavement Construction	Construction considerations to improve pavement sustainability, future directions, and emerging trends	January 30, 2020 2:30–3:30 PM ET
5	Maintenance and Preservation	Pavement preservation basics, impacts of preservation on sustainability, sustainable preservation techniques	February 13, 2020 2:30–3:30 PM ET
6	EOL Considerations	End-of-Life (EOL) considerations related to pavement sustainability, EOL options for asphalt and concrete pavements	March 19, 2020 2:30–3:30 PM ET
7	LCCA Part I: Fundamentals	Life-Cycle Cost Analysis (LCCA) concepts, steps in pavement LCCA process, tools to conduct LCCA	April 16, 2020 2:30–3:30 PM ET
8	LCCA Part II: Applications	Key considerations in pavement LCCA, example LCCA applications in sustainability-related applications	May 21, 2020 2:30–3:30 PM ET
9	LCA Part I: Fundamentals	Life-Cycle Assessment (LCA) concepts, benefits and uses; steps in the pavement LCA process; tools and resources on LCA	June 18, 2020 2:30–3:30 PM ET
10	LCA Part II: EPDs and PCRs	Fundamentals on Environmental Product Declarations (EPDs) and Product Category Rules (PCRs)	July 23, 2020 2:30–3:30 PM ET

For More Information

- FHWA Sustainable Pavements Website
  - www.fhwa.dot.gov/pavement/sustainability

- FHWA Contacts:
  - Heather Dylla (Heather.Dylla@dot.gov)
  - Monica Jurado (Monica.Jurado@dot.gov)

Q&A

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