U.S. Department of Transportation
Federal Highway Administration

Turner-Fairbank
Highway Research Center

Progress Toward More Resilient and Sustainable Pavements

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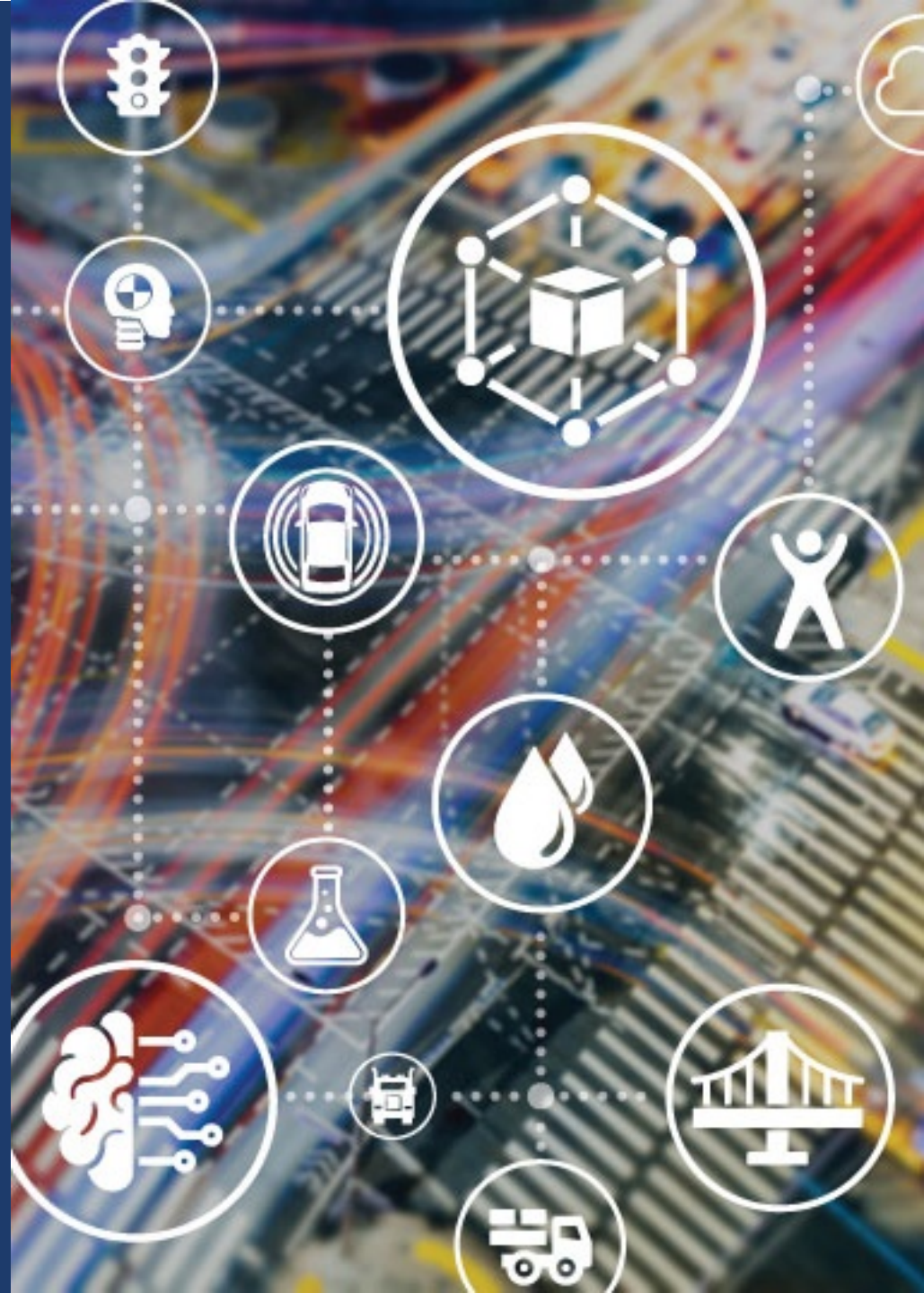
Office of Research, Development, and Technology
Federal Highway Administration (FHWA)

The IRF Global R2T Conference
November 16th, 2023



Resilience is *not* sustainability

Sustainable + Resilient Practices or Attributes

Sustainable Practices or Attributes
- Use of recycled materials
- Cold Recycled Asphalt
- Asphalt mix and plant optimization

Sustainable + Resilient Practices or Attributes
- Warm Mix Asphalt (low emissions + increase in haul distance)
- Porous pavement systems (stormwater management + nuisance flooding)
- Perpetual Pavement Design
- Deep reconstruction of pavement (increase deep layer moduli)
- Rapid construction
- Ability to adjust pavement design to climate / climatic events to extend pavement life

Resilient Practices or Attributes That Are Not Sustainable
- Use of novel materials with unknown environmental or safety risks
- Use of climate adaptable materials when the social and environmental benefits do not outweigh the costs (e.g., use of polymer modified binders for low volume roads)
- Over-designing for low-risk catastrophic events

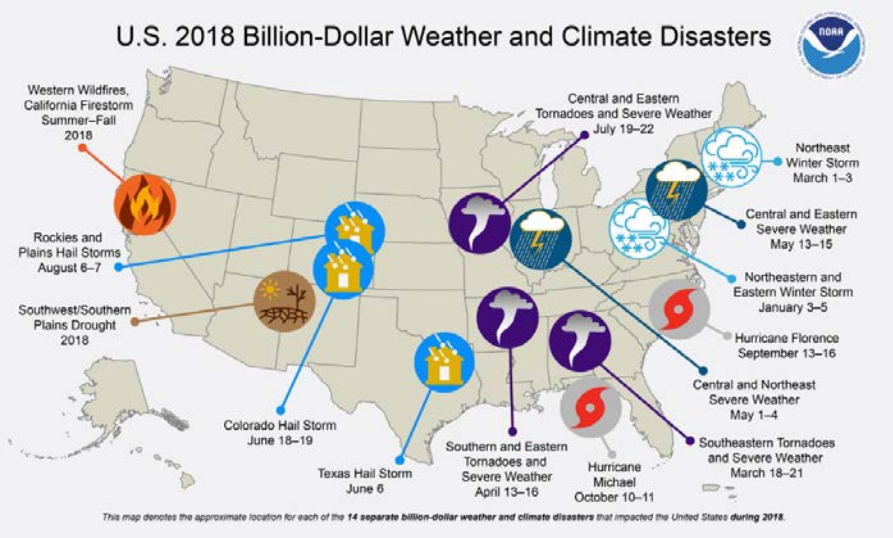
Figure 1. Venn Diagram of Sustainable, Resilient, and Resilient + Sustainable Practices and Attributes for Asphalt Pavements

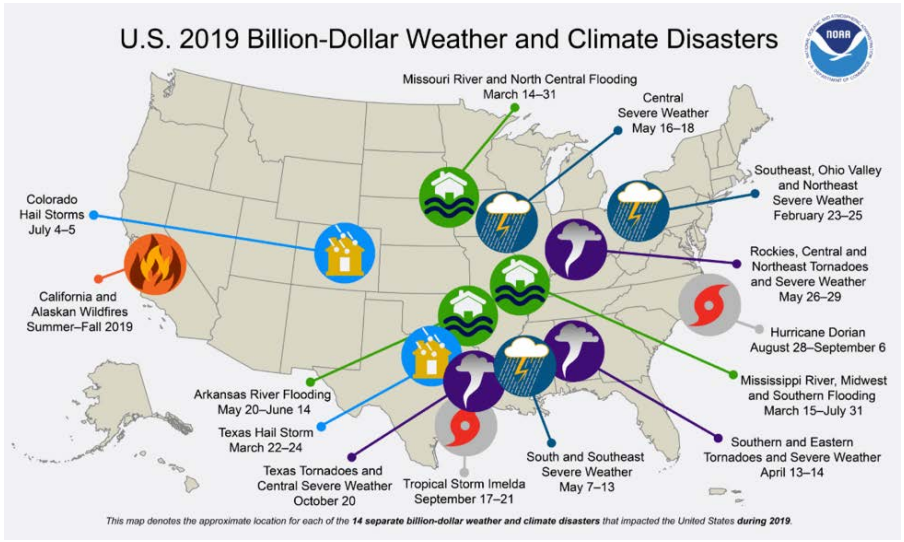
owers and Gu (2021) "Resilient halt Pavements: Industry utions for the Resilience Goal", PA SIP 105

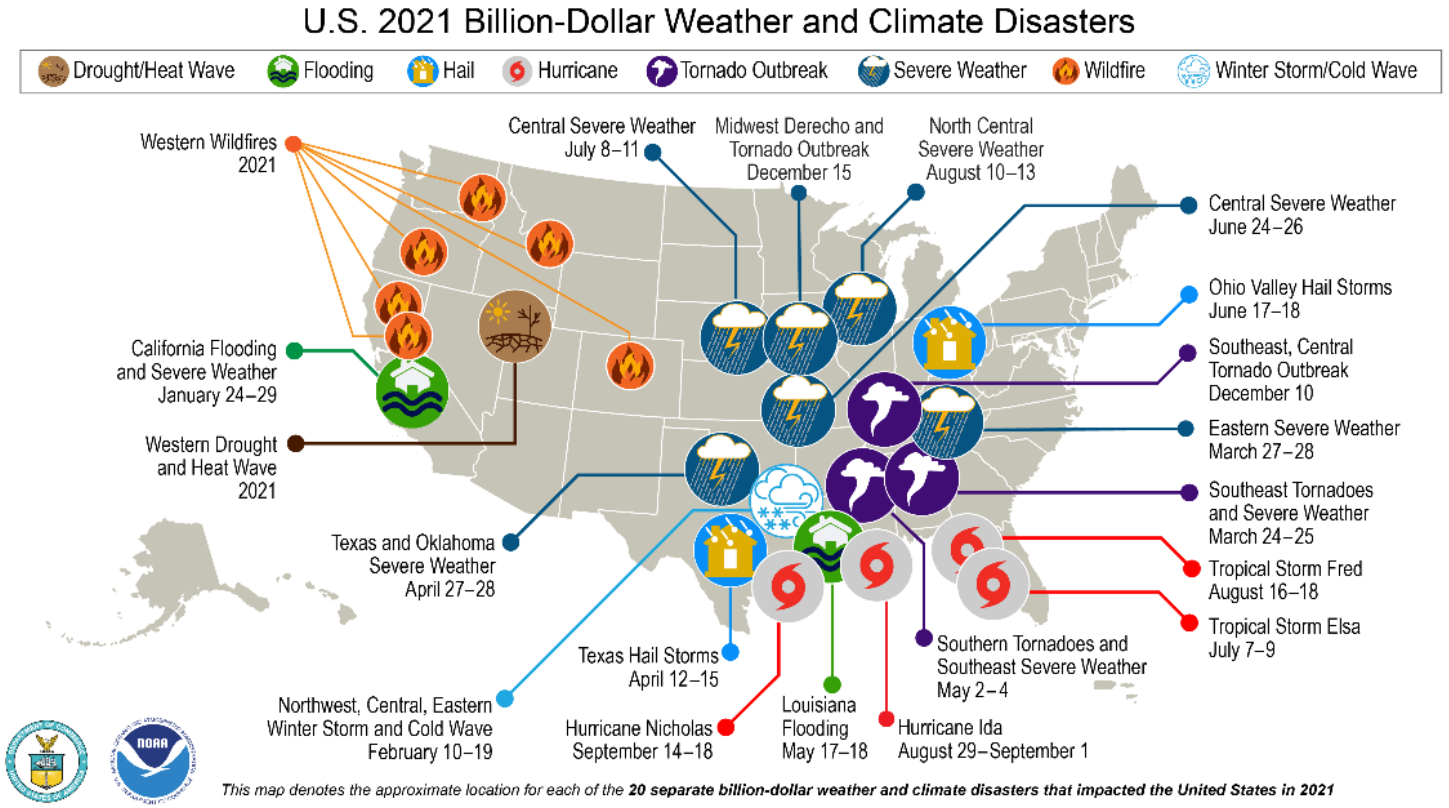
Resilience is *not* sustainability

However…
While resilient solutions may or may not be sustainable… a resilient system contributes to sustainability…

The Impact of Climate!







Why Sustainability Matters!

While we need resilience to withstand the extreme weather events, we need sustainability to mitigate the climate crisis....

FHWA Sustainability

Application to Pavements

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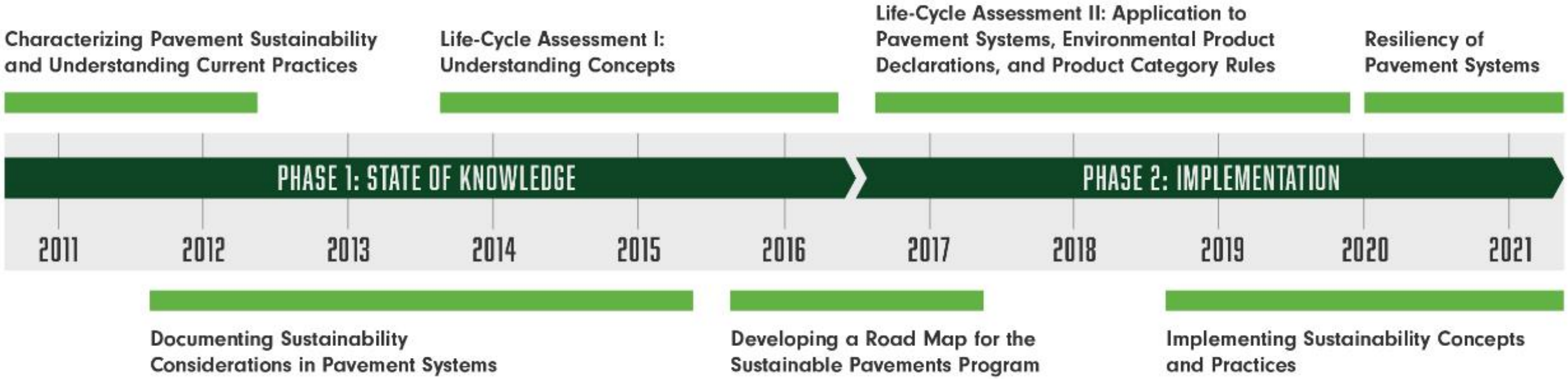
Program Vision

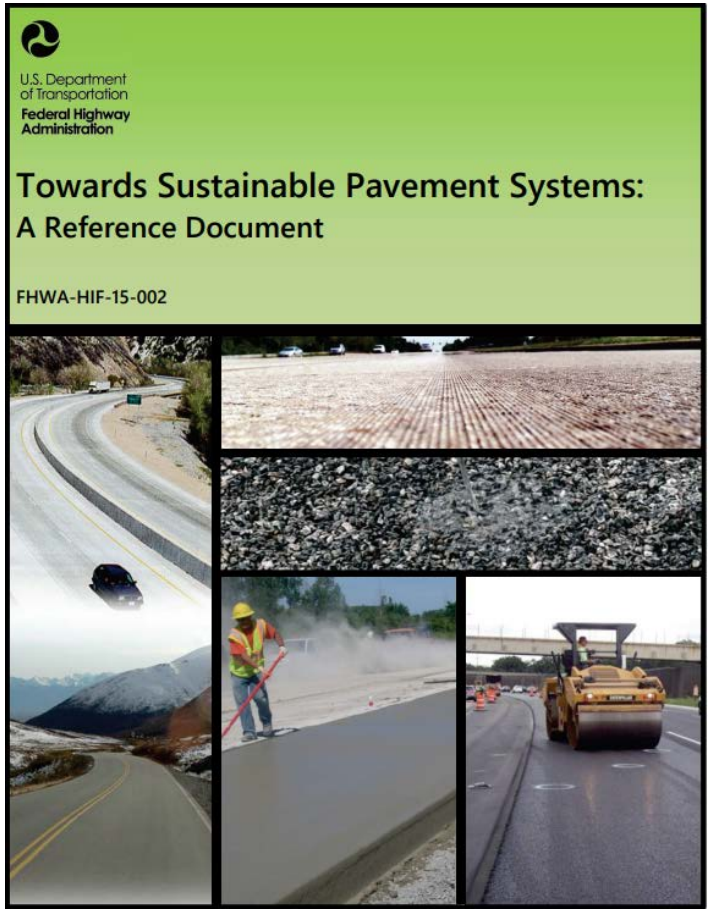
Ensure that pavements are designed, constructed, preserved, and maintained to accommodate current and predicted traffic needs and consider economic, environmental, and social impacts and burdens throughout the pavement's life cycle.

+10 Years of Activity



Sustainable Pavements Reference Document

- Documents sustainability considerations in pavement life-cycle stages:
  - Materials
  - Design
  - Construction
  - Use
  - Maintenance and Rehabilitation
  - End of Life

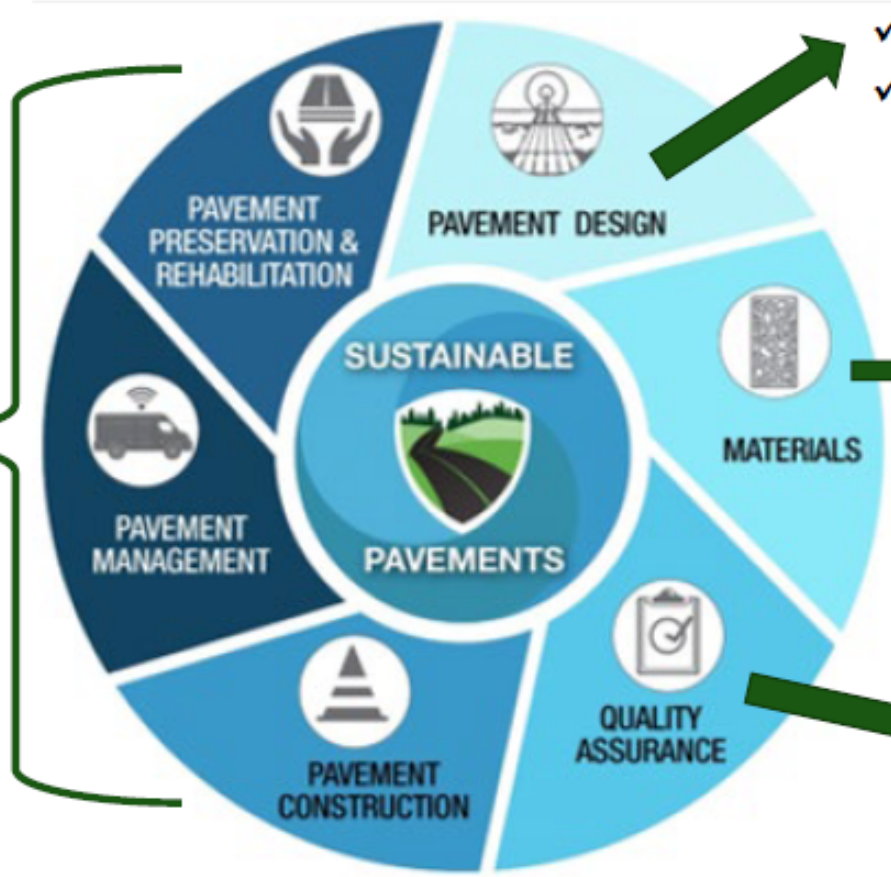


https://www.fhwa.dot.gov/pavement/sustainability/ref_doc.cfm

Sustainable Pavement Program

SPP Initiatives At a Glance

- ✓ Climate Challenge
- ✓ WH Buy Clean TAG
- ✓ US DOT Embodied Carbon Working Group
- ✓ Green Public Procurement – Global Benchmark Study
- ✓ Buy Clean Policies
- ✓ EPDs
- ✓ EDC7 – EPDs for Sustainable Project Delivery
- ✓ NHI Training Course

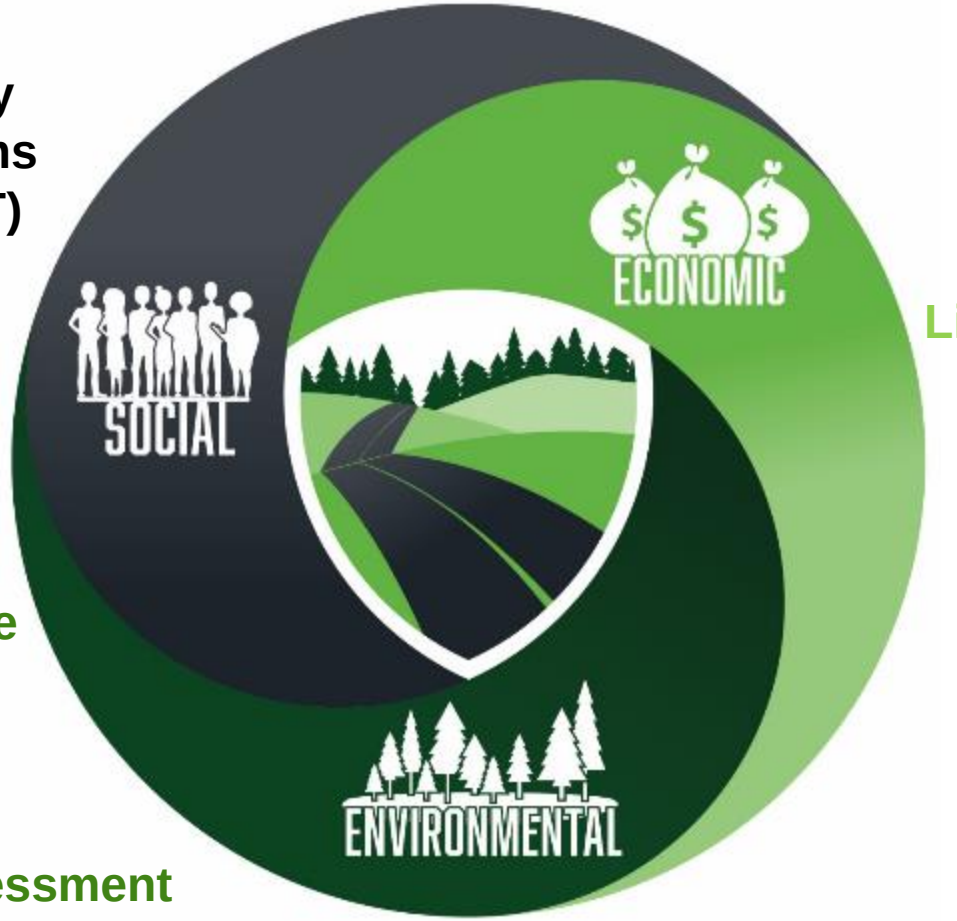


- ✓ LCA Pave Tool
- ✓ Pavement Design Policy NPRM
- ✓ Development of LCA Case Studies
- ✓ IRA "Lower embodied carbon materials"
- ✓ MATC/MCTC LCA Case Studies
- ✓ Research Projects

- ✓ NCHRP 10-123 Quality Assurance and Sustainability
- ✓ IRA – QA for recipients

Balance of the Triple Bottom Line

Sustainability Rating Systems (e.g., INVEST) Social LCA (S-LCA)



Performance Testing

⇩

Life-Cycle Cost Analysis (LCCA)

Performance Testing

⇩

Life-Cycle Assessment (LCA)

Image Source: FHWA/APTech

SPP Programmatic Initiatives

WH Buy Clean Initiative
14057 specified goal towards Federal Buy Clean Policy for federally

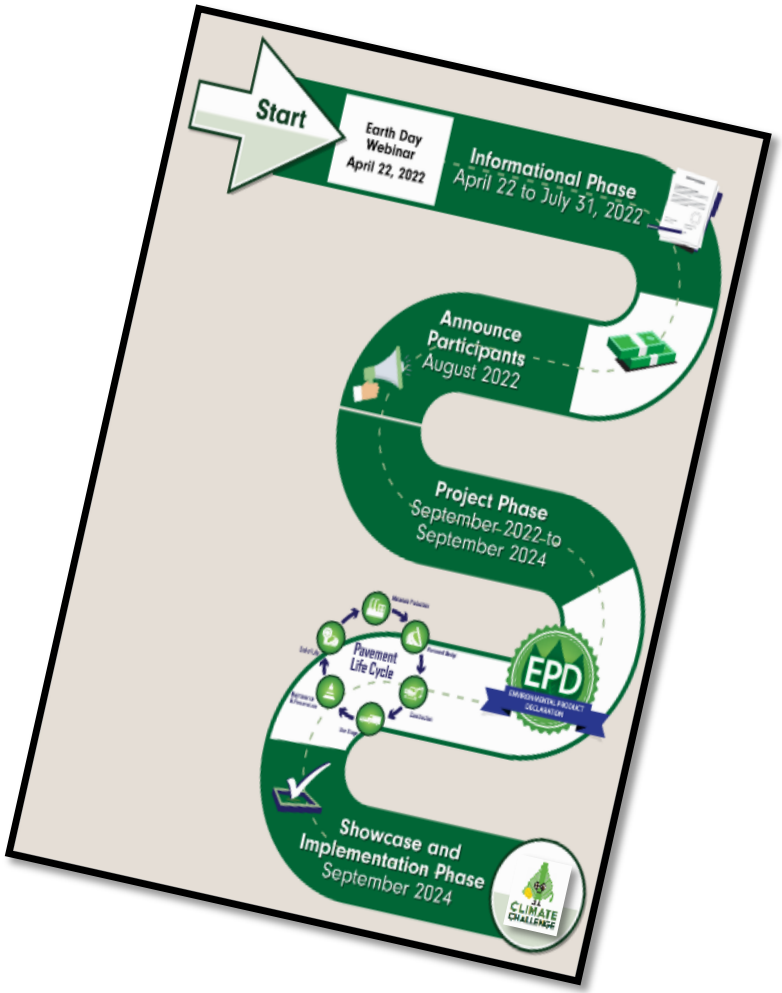
Inflation Reduction Act
$2 Billion for FHWA
Low-carbon transportation materials grants (P.L. 117-169)

25 States (+2 Locals) Participating
FHWA supporting 35+ projects from 27 agencies with $7.1M

EDC-7 State DOTs
EPDs for Sustainable Project Delivery

Climate Challenge; Quantifying the Emissions of Sustainable Pavements

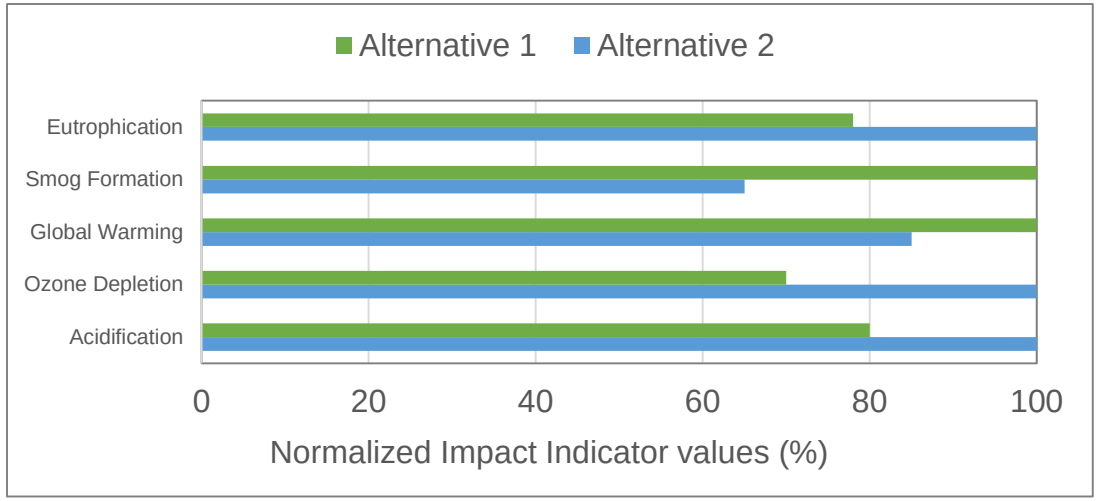
- Quantify GHG emissions of pavements through the implementation of LCA and EPDs
- Challenge participants with eligible proposals will be selected on a rolling basis until funding is no longer available
- **Up to $500k** is available per DOT (funding may require a match contribution by the DOT)
- For the latest information, visit the website: https://highways.dot.gov/climatechallenge

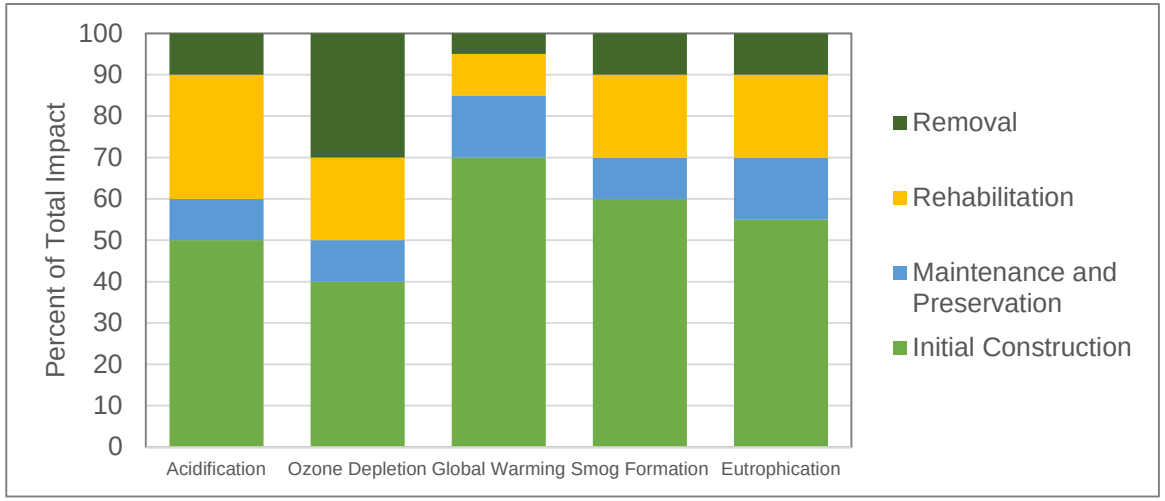


LCA Benchmarking Tool

LCA PAVE

- Created with stakeholder input
- Use the identified background datasets
- Incorporate material EPDs





Available at: https://www.fhwa.dot.gov/pavement/lcatool/

Resources

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

Education	Research	Deployment
Pavement LCA Framework	LCA fit in transportation decision-making	LCAPave Tools
Webinars	EPDs in Green Public Procurement	Pilot projects with State DOTs
Tech briefs, studies	LCA of recycled plastics in pavements	Mobile Pavement Technologies Centers
Technical articles	LCA of ground tire rubber in pavements	Informing pre-engineering with ICE Tool

FHWA Resilience

Ongoing Pavement Related Efforts

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What Is Resilience?

Resilience: The ability to anticipate, prepare for, and adapt to changing conditions and withstand, respond to, and recover rapidly from disruptions, FHWA Order 5520 (FHWA 2014c).

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Environmental Impacts on Pavements

- Environmental factors contribute to pavement distresses, such as blowups, buckling, rutting, and thermal cracking.
- The Long-Term Pavement Performance Program studied environmental factor impacts on pavement performance (FHWA 2016b):
  - There is 36 percent of total damage for flexible pavements.
  - There is 24 percent of total damage for rigid pavements.
- Pavements are designed using climatic data; however, engineers typically assume stationarity.

Potential Consequences with Assuming Stationarity for Flexible Pavements

Higher average temperature	Increased potential for rutting and shoving, requiring more rut-resistant asphalt mixtures. Increased age hardening of asphalt binder.
Moisture changes	Increased potential for soil shrinking and swelling, particularly in times of drought, requiring stiffer pavement designs.
Increased precipitation	Reduced pavement structural capacity due to increased levels of saturation, potentially requiring base stabilization, a better understanding of foundation design, and improved mix designs.

(FHWA 2015)

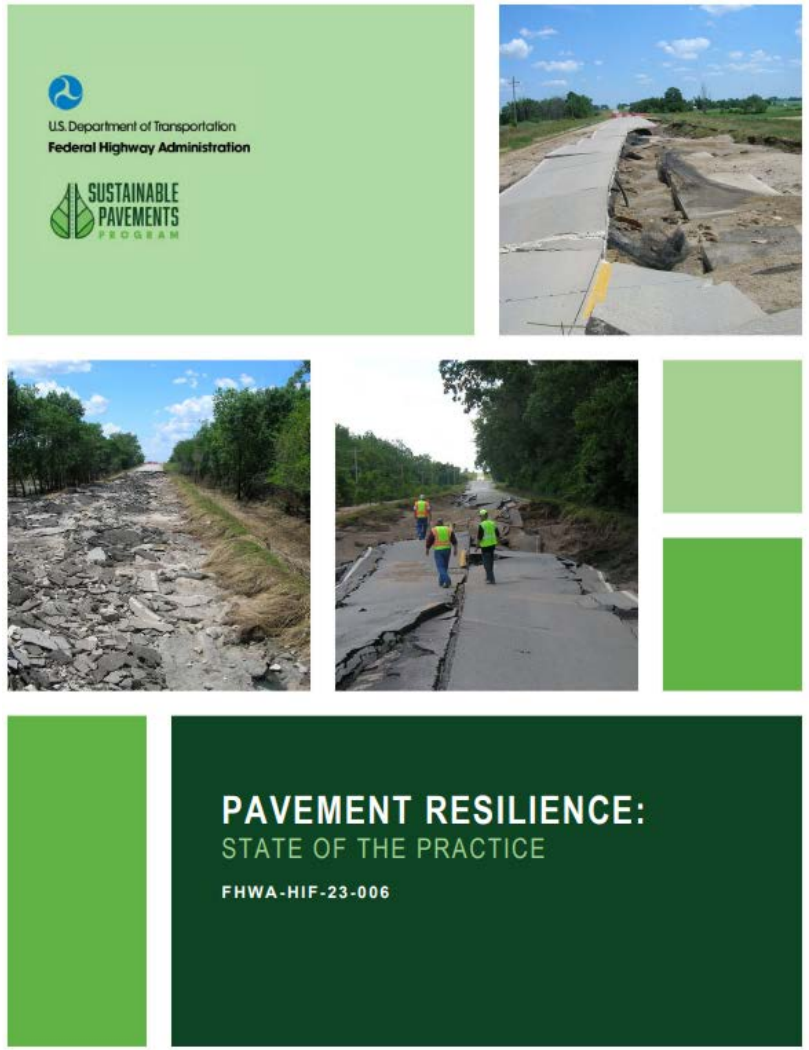
Possible Solutions for Pavement Vulnerabilities

Climate Change Stressors	Strategies
More Extreme Rainfall	Apply high-friction surface treatments. Use porous pavements or open-graded friction courses.
Higher Average Precipitation	Reduce moisture susceptibility of unbound base/subgrade materials through stabilization. Ensure asphalt mixtures' resistance to moisture susceptibility.
Wetter Winters and Drier Summers	Incorporate soil modification/stabilization into design. Use stiffer/improved pavement designs that are less susceptible to changes in subgrade properties. Ensure concrete freeze-thaw resistance. Ensure concrete in joint design remains below critical saturation.
Low Summer Humidity	Add asphalt binder antiaging additives. Pavement preservation to address binder aging. Reduce drying shrinkage of concrete mixes by decreasing paste volume. Consider concrete drying shrinkage in design by reducing slab length.
Higher Average Temperature	Raise asphalt binder grade or consider polymer modified binders. Exercise greater consideration of concrete coefficient of thermal expansion and drying shrinkage. Incorporate design elements to reduce damage from thermal effects in concrete pavements, including shorter joint spacing, thicker slabs, less rigid support, and enhanced load transfer.
Higher Extreme Maximum Temperature	Consider polymer-modified binders. Use shorter joint spacing in concrete designs. Keep joints clean and, in extreme cases, install expansion joints in existing pavements.
More Freeze-Thaw Events in Some Locations	Increase consideration of the thermal fatigue characteristics of asphalt binder.

Resilient Pavements Roadmap

- What are the current gaps and future needs?
  - Pavement resilience peer exchange.
  - Highway resilience to wildfire events.

- What education resources are available to incorporate more resilient practices?
  - Pavement resilience technical guidelines (Recently Published).
  - Pavement resilience website: In progress.



Assessing Flooded Pavements Project

- Project objectives:
  - Develop methods to assess flooded pavements.
  - Assess the capacity to carry traffic during/after flooding.
  - Evaluate emergency or heavy equipment.
  - Evaluate normal traffic.
  - Determine the tradeoff between the user costs of road closure (and detours) versus the costs of increased road damage.
  - Develop a decision support tool.
- Project deliverables: A report is in publication (FHWA forthcoming a).

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Impacts of Wildfires on Transportation Assets

- Project objectives:
  - Determine the state of knowledge of wildfire impacts on pavements and other assets.
  - Define direct and indirect impacts.
  - Identify research gaps and needs.
- Project deliverables:
  - Determine the state of knowledge.
  - Identify how State DOTs deal with this issue:
    - Conduct detailed interviews.
    - Gather information on their experiences, observations, and challenges.

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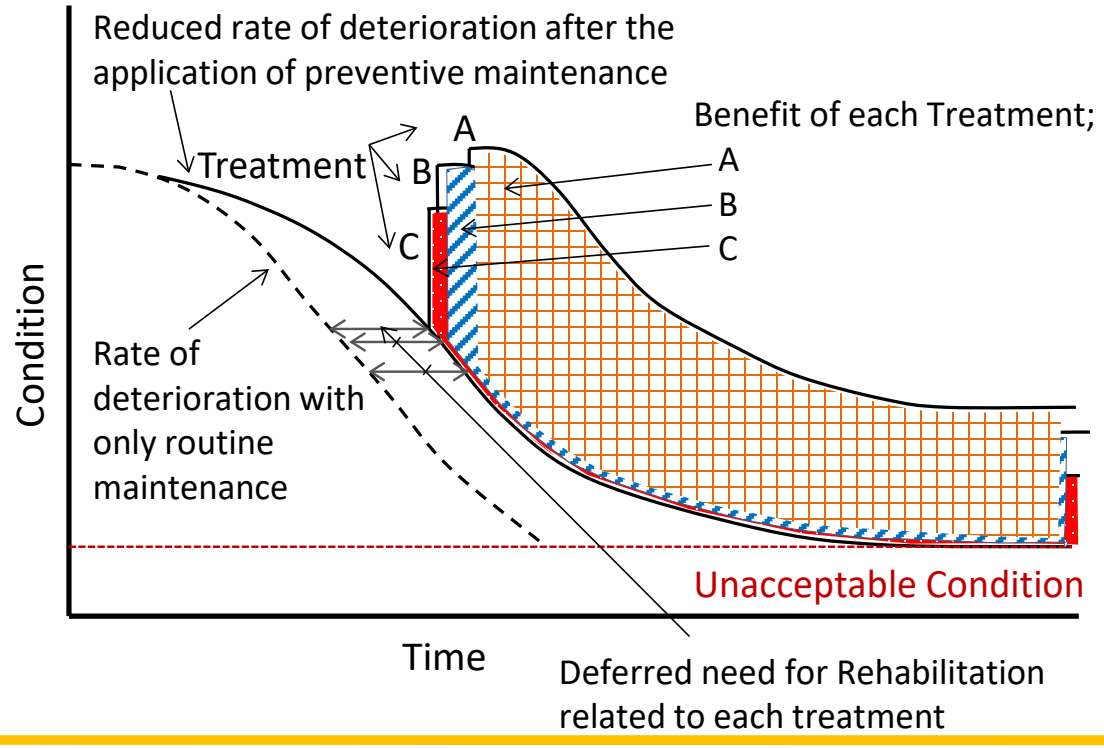
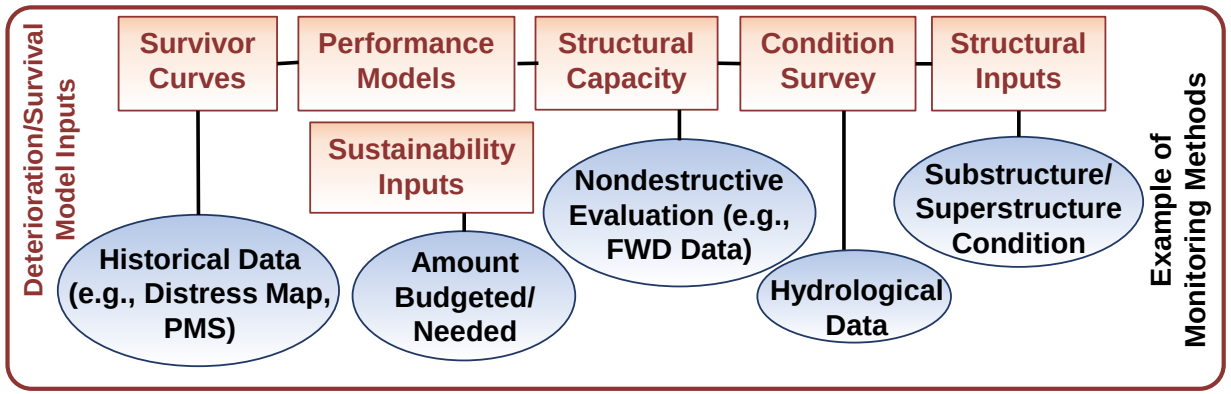
Upcoming Projects/Efforts

- Impact of Environmental Factors on Transportation Infrastructure—Different datasets will be used for the development of deterioration models.





Upcoming Projects/Efforts

- Dissemination of Available Knowledge on Infrastructure Resilience—A series of technical webinars, workshops, and a TechBrief.

- Holistic Framework for Project-Level Resilient Pavement Adaptation and Engineering Design—Future climate projection incorporation for resilient mechanistic-empirical pavement design.

NEW: Transportation Pooled Fund on Resilience

New Pooled Fund Project (TPF-5(512)):
Resilience Approaches for Pavements and Geotechnical Assets

Transportation Pooled Fund - Study Detail

Home › Studies › Resilience Approaches for Pavements and Geotechnical Assets

Resilience Approaches for Pavements and Geotechnical Assets

Print

General Information

Study Number:	TPF-5(512)
Former Study Number:	
Lead Organization:	Virginia Department of Transportation
Solicitation Number:	1590
Partners:	FL, HI, MDOT SHA, PADOT, TX, VA, WA
Status:	Cleared by FHWA
Est. Completion Date:	
Contract/Other Number:	
Last Updated:	Apr 27, 2023
Contract End Date:	

Financial Summary

Contract Amount:	
Total Commitments Received:	$660,000.00
100% SP&R Approval:	Approved

Contact Information

Lead Study Contact(s):	Shabbir Hossain Shabbir.Hossain@VDOT.Virginia.gov Phone: 434-293-1989
FHWA Technical Liaison(s):	Amir Golalipour amir.golalipour@dot.gov Phone: 2024933089

TRB AKM20 Subcommittee

Sustainability and Resilience

U.S. Department of Transportation
Federal Highway Administration
Turner-Fairbank Highway Research Center

Sub-committee Task Forces

- Definition of acronyms - Heather Dylla & Anja Sörensen
- Determine the target audience and survey planning - Jhony Habbouche
- Identification of sustainability impacts & strategies - Anja Sörensen
- Resilience - Amir Golalipour

Task Force Definition of Acronyms

- TRB circular near complete; include both definitions and terms:
  - plan to send out for broader committee review hopefully by the end of June

- Provided to AASHTO: under ballot

Acronym	Wording	Definition or description	Comments, e.g. information from specific countries, regions
CCIA	Climate Change Impact Assessment	A tool which considers the projected increased frequency and intensity of extreme weather events and their impacts on the performance of a product over its life cycle. (2)	
Circular Economy		(An economy …) where the value of products, materials and resources is maintained in the economy for as long as possible, and the generation of waste minimised, … (1)	No legal definition available Definition for this is still very much in developement in my opinion. But I suppose it is very similar to reuse/recycle from a pavement perspective.

Task Force Identification of Sustainability Impacts and Strategies

- Document on sustainability impacts and strategies – sections:

  1. **Re-use/Recycling**, and from this also reduction of use of new raw material
  2. **Durability** and maintenance
  3. **Innovative** materials and reduction of use of new raw material
  4. **Reduction** in emissions and energy use
  5. **Others**

- TRB E-Circular

Environmental / ecological	Economical	Social
Durability (resource use) • Durability of material or durability of structure? • Long term service life of asphalt pavement, which may be described by e.g. rutting resistance, cracking	Durability (investments) • Long term service life of asphalt pavement, which may be described by e.g. rutting resistance, cracking resistance, fatigue resistance – basically anything with an	Durability (use and maintenance of pavement) • Congestions from maintenance or other construction works • Safety of workers • Safe driving

Workshop at TRB 2024

- **Workshop Title**:
  Flexible Pavements & Binders - Sustainability Aspects from International Perspectives

- **Targeted Topics**:
  Social Sustainability
  Pavement Vehicle Interactions
  Green House Gas Reduction
  Environmental Product Declaration & Product Category Rules
  Bio and Alternative Materials

- Date: **Thursday, January 11th**

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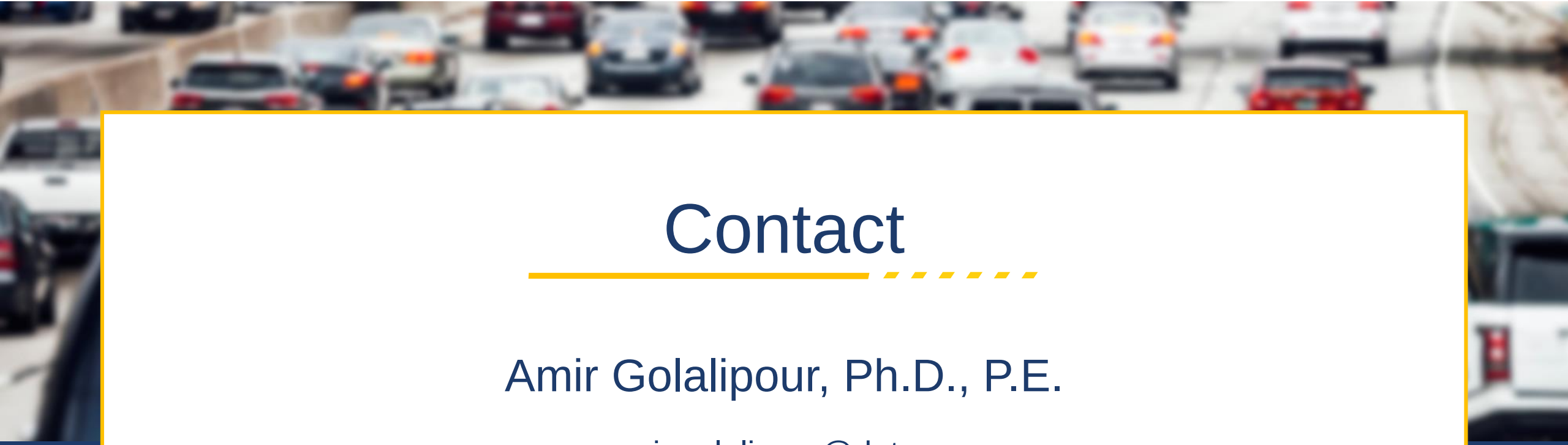

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