Putting Sustainability into Practice

October 26, 2023

PAAMA: Pennsylvania Association of
Asphalt Material Applicators Annual Conference

Boalsburg, PA

Dr. Andrew Braham, Professor
University of Arkansas

UNIVERSITY OF ARKANSAS

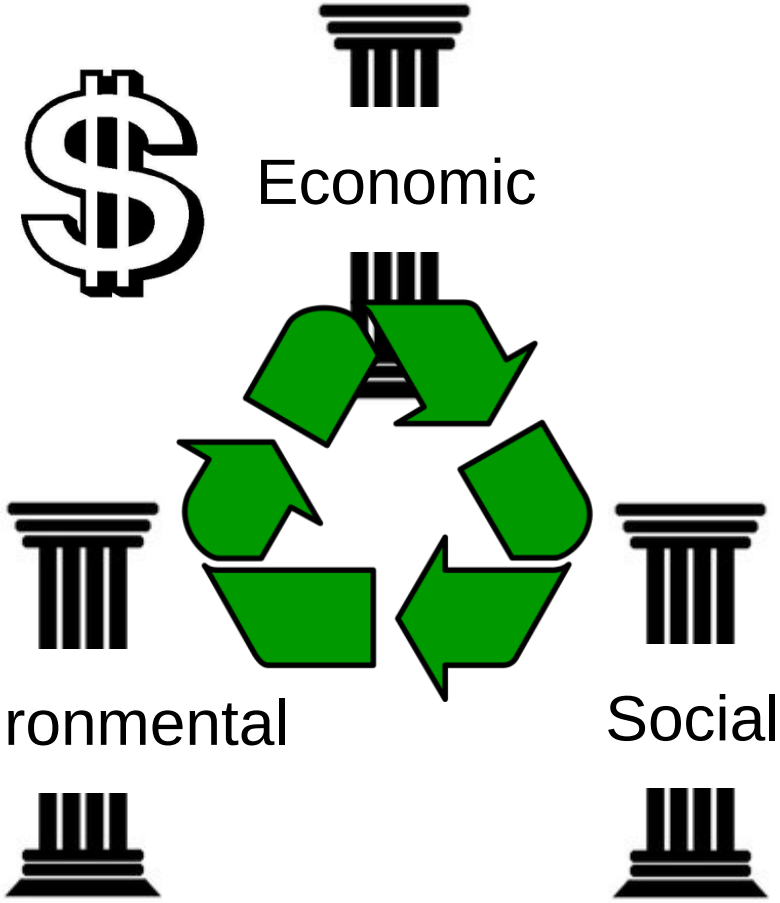
PAAMA
Pennsylvania Association of Asphalt Material Applicators

Overview

- What is sustainability?
- Practice 1: the three pillars
  - Economic: LCCA
  - Environmental: LCA, PCR, EPD
  - Social: HDI, SIA
- Practice 2: recycled/alternate materials
  - Asphalt binders: rubber, plastics, etc.
  - Asphalt mixtures: RAP, RAS, WMA, CMA, etc.
- Practice 3: planning
  - Preservation, maintenance, rehabilitation
  - Pavement management systems

(sustainability.psu.edu)

Sustainability: three pillars



(images from: thecancershow.com, 123rf.com, blastmedia.com, stock.adobe.com)

How does ASCE handle sustainability?

ASCE and sustainability

- First fundamental principle
  - "using their knowledge and skill for the enhancement of **human welfare** and the **environment**"
- First fundamental cannon
  - "Engineers shall hold paramount the **safety**, **health** and **welfare** of the public and shall strive to comply with the principles of **sustainable development** in the performance of their professional duties"

(asce.org)

- Definition of sustainable development
  - "The process of applying **natural**, **human**, and **economic** resources to enhance the **safety**, **welfare**, and **quality of life** for all of the society while maintaining the availability of the remaining **natural resources**"

Let's dig into the three pillars

Economic pillar

- Life Cycle Cost Analysis (LCCA)
  - Long-term economic analysis
  - Initial and discounted future costs
  - Economic comparison of different strategies
- Six steps
  - Establish alternative design strategies for analysis period
  - Determine performance periods and activity timing
  - Estimate agency and user costs
  - Develop expenditure stream diagrams
  - Compute net present value*
  - Analyze results and reevaluate design strategies

Economic

Search “Life Cycle Cost Analysis Pavinar” on Youtube

*Rex said I had to show at least one equation

Compute net present value (NPV)

$$NPV = I + \left(\sum_{n=1}^{t} \frac{Annual\ Maint}{(1+i)^n} \right) + \frac{Sched.Maint}{(1+i)^n} + \frac{Sched.Rehab}{(1+i)^n} - \frac{Salvage}{(1+i)^t}$$

- I : Initial costs
  - Agency, user
- Maintenance cost
  - Annual (every year)
  - Scheduled in year “n”
- Rehabilitation costs
  - Scheduled in year “n”
- Salvage value
  - At end of life “t”

$$= \left[CLT \times \left(\frac{RLLT}{SLLT} \right) \right] + CRI$$

i : discount value (dec)

n: year

t : design life (years)

CLT = cost of last treatment

RLLT = remaining life of last treatment

SLLT = service life of last treatment

CRI = cost of lower layers remaining from initial construction

What about environmental pillar?

Environmental pillar: flow of terms

Environmental

Life Cycle Assessment

Product Category Rule

Environmental Product Declaration

Let’s go over each of these terms

Life Cycle Assessment (LCA)

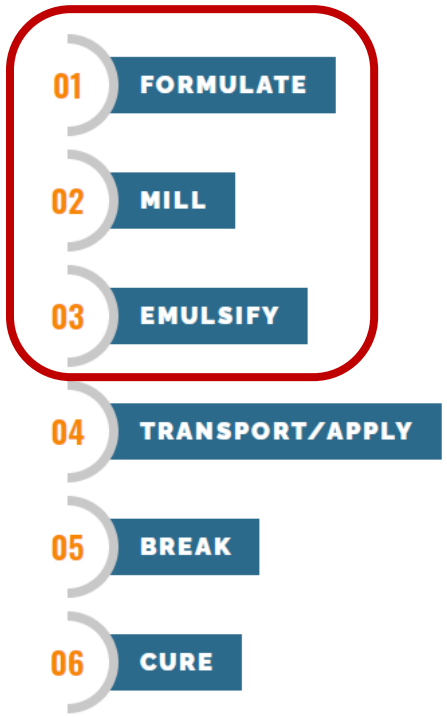
- Compile and quantify inputs/outputs of four stages
  - Product/materials, construction, use, end of life
  - Called “environmental flows”
- Inputs to LCA
  - Extraction, transportation, manufacturing, maintenance, etc.
- Outputs to LCA
  - Fuel/electricity use, waste (solid, liquid, hazardous), emissions, etc.
- Translate environmental flows to environment/human impacts
  - Impacts: depletion of resources, human health, ecosystem
  - Categories: energy use, resource use, emissions, toxicity, fresh water use, hazardous waste

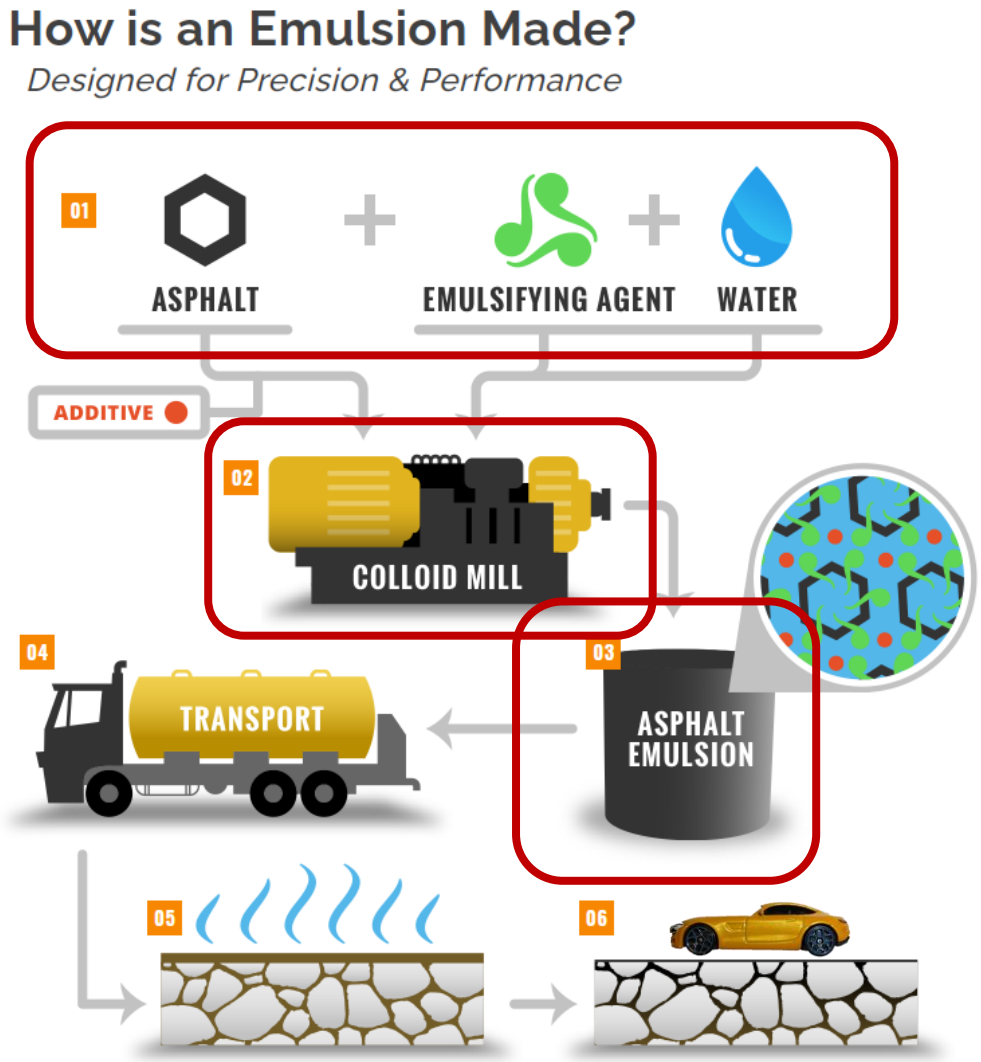
Example: asphalt emulsion

Asphalt emulsion life cycle:

from RoadResource.org

"Cradle to gate"





An LCA for asphalt emulsion is in final draft form

Next: PCR

Product Category Rule (PCR)

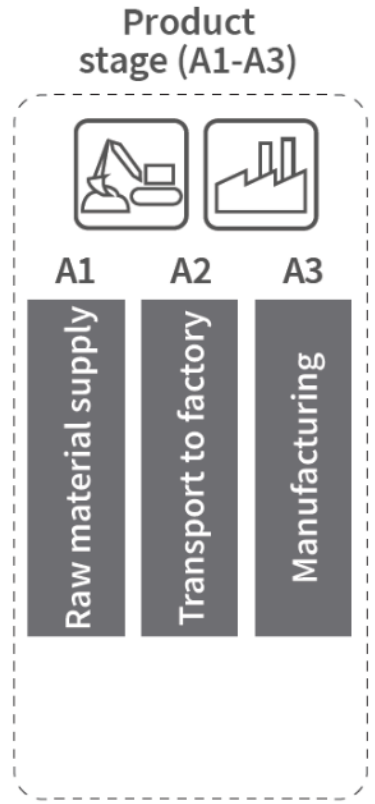
- Set of rules, requirements, guidelines for developing EPDs
- Main components
  - Definition and description
  - Goal and scope, stages
  - Environmental flows
  - Environment/human impacts
  - Materials and substances to be declared
  - Instructions for producing data, content, and format
  - Period of validity (five years)
- Third party review panel is required

(roadresource.org)

Next: EPDs

Environmental Product Declaration (EPD)

- Motivation: multiple agencies moving forward incorporating/requiring EPDs
  - California, Colorado, Oregon, Minnesota, New York, New Jersey, Washington, General Service Administration (GSA)
  - They are coming!!
- Eight national average EPDs being developed for asphalt emulsion
  - Polymer vs. non polymer
  - With and without fuel oil, rejuvenator
  - Diluted or un-diluted
- Only product/manufacturing stage



(CLF, 2021)

What does an EPD give you?

One example from National Asphalt Pavement Association

PARAMETER	UNIT	A1	A2	A3
Global Warming Air, incl. Biogenic Carbon	[kg CO2-Equiv.]	22.9	2.34	2.86
Ozone Depletion Air	[kg CFC 11-Equiv.]	4.84e-09	9.89e-11	2.1e-11
Acidification	[kg SO2-Equiv.]	0.133	0.0114	0.00693
Eutrophication	[kg N-Equiv.]	0.00794	0.000737	0.000433
Smog Air	[kg 03-Equiv.]	2.36	0.358	0.275
Abiotic Depletion for Fossil Resources	[MJ surplus energy]	MND*	MND*	MND*

A1: materials A2: transport A3: production

1 short ton asphalt mixture (dense graded, 3/4” NMAS, 0% RAP, hot mix)

What about the social pillar?

Social pillar

- Human Development Index (HDI) – United Nations
  - Human wellbeing beyond economic measures
  - Long/healthy life (life expectancy at birth)
  - Being knowledgeable (expected years of schooling)
  - Decent standard of living (gross national income per capita)
- Social Impact Assessment (SIA)
  - Enhance lives of vulnerable/disadvantaged people
  - Characteristics: participatory, supports people/organizations, increases understanding/capacity of social impacts
  - Categories: way of life, culture, community, political systems, health and well-being

Recycled/alternate materials: asphalt binders

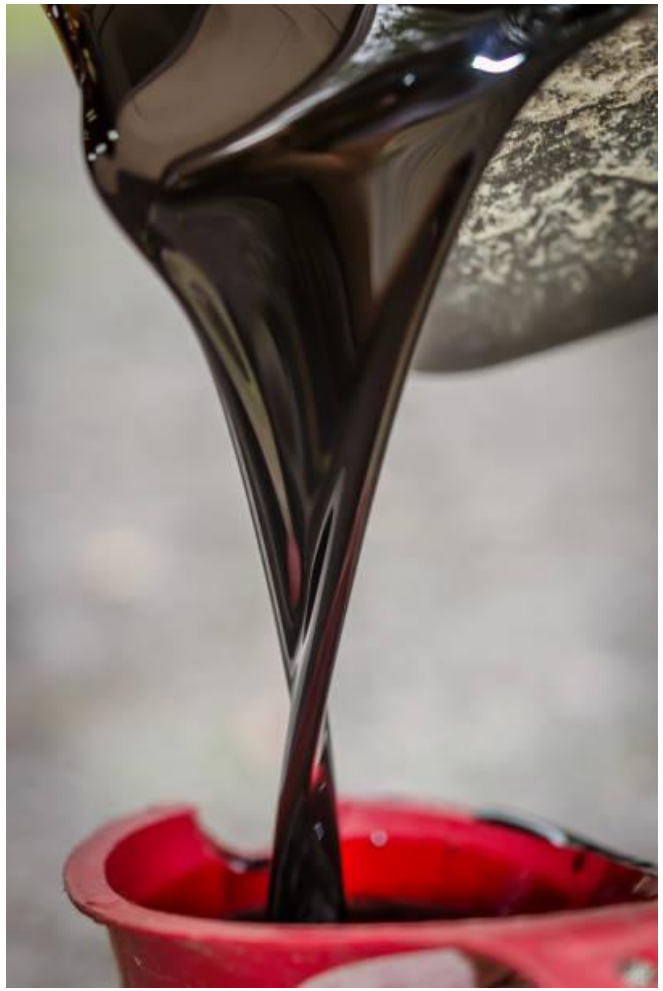
- Recycled tire rubber
- Recycled engine oil binders
- Recycled plastic
- Bio-binders

(azocleantech.com)

Let’s walk through these four

Tires and oil

- Recycled tire rubber
  - <25% binder replacement
  - Add ground tire rubber to asphalt binder
  - “Wet” process theoretically replaces polymer, “dry” process not as typical
  - Used extensively in Arizona, California, Georgia
- Recycled engine oil binders
  - <25% binder replacement
  - Blending agent to soften binders
  - Literature is mixed on performance
  - See Asphalt Institute IS235



(istockphoto.com)

Plastic and bio-binders

- Recycled plastic
  - <12% binder replacement
  - Limit to LDPE and HDPE (low/high density polyethylene)
  - See NCHRP Project 9-66 interim report
- Bio-binders
  - <20% binder replacement
  - Three main types: plant fiber oils, animal manure, waste oil
  - In general, improves low temp but decreases high temp properties
  - Performance highly dependent on oil source

(plasticexpert.co.uk)

What about mixtures?

Asphalt mixtures: RAP and RAS

- RAP: reclaimed asphalt pavement
  - NAPA IS-138: 101.3M tons, saved $3.4B materials and $5.1B landfill gate fees
  - Average use 20.8% (agency), 25.1% commercial/residential
- RAS: recycled asphalt shingles
  - NAPA IS-138: 630,000 tons, saved $69M materials and $21M landfill gate fees
  - Average use 0.15% total
- Moving toward RBR: recycled binder ratio
  - Recycled binder / total binder content
- Check out NCHRP Synthesis 495 (RAP & RAS)
- Keep an eye out for NCHRP 09-65 and 09-68

(sripath.com)

Asphalt mixtures: WMA

- Many options over the years
  - Less impactful: blast furnace slag, steel slag, fly ash, recycled foundry sand, recycled glass
  - The big three: WMA, RAP, RAS
- Warm Mix Asphalt (WMA)
  - NAPA Information Series 138 (IS-138, free, 2021)
  - 178 million tons in (~41%)
  - 10-50°F drop (~98%)
  - Chemical (60%) and foam (38%) biggest

(vaasphalt.org)

Can we go lower?

Weighted Average Temperature Reduction[1]	Mix Production Energy Reduction (trillion Btu)	Mix Production GHG Emissions Reduction (MMT CO_2e)	Upstream GHG Emissions Burden (MMT CO_2e)	Net GHG Emissions Reduction (MMT CO_2e)	Equivalent Number of Passenger Vehicles[2]
23.5°F	2.2	0.16	0.080	0.080	17,000

Note, State College ~40,000

Yes! Cold Mix Asphalt (CMA)

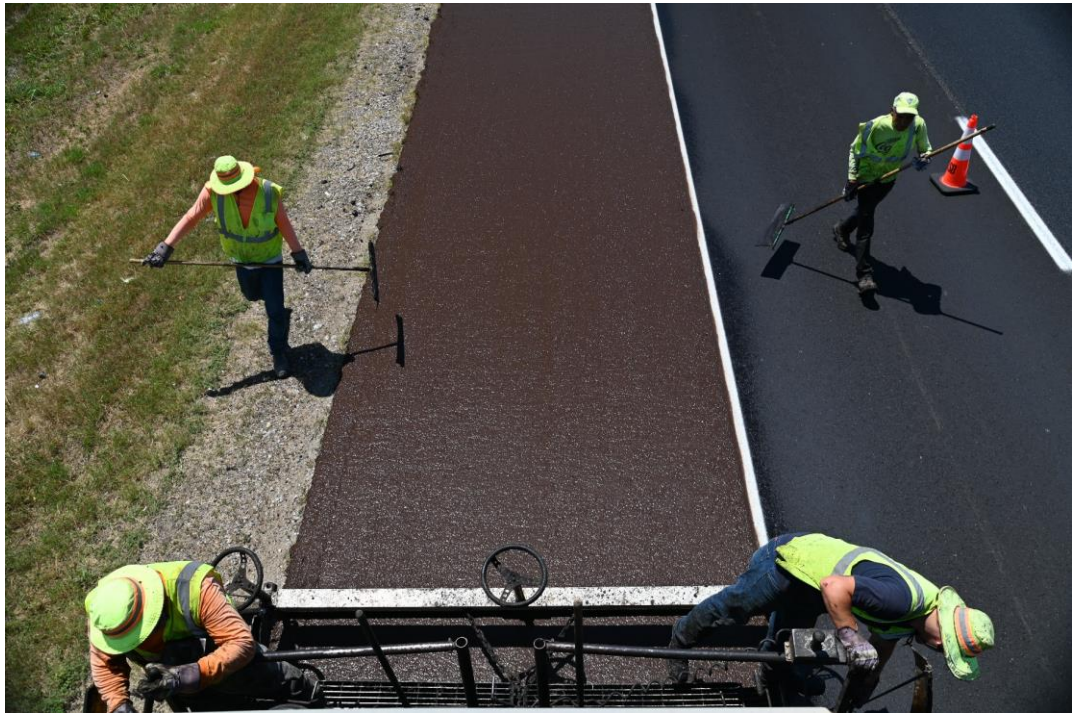
- Cold Mix Asphalt (emulsion and foam)
  - Cold In-place Recycling (CIR)
  - Cold Central Plant Recycling (CCPR)
  - AASHTO MP 31, MP 38, PP 86, PP 94
- Thrives in lower layers of pavement
  - Semi-bound material, 100% RAP
  - Can be used on low, medium, and high traffic roads (up to interstates)
  - Lots of work done in Virginia, NCAT (see recent 2023 construction guidelines: NCHRP Web-Only Document 363)
- More work to be done
  - Field strength/acceptance test
  - Inclusion into balanced mix design

CIR single-unit train

Now to Practice 3: planning

Planning

- Preservation
  - Keep good roads in good condition
  - Network level
- Maintenance
  - Taking care of a road's surface
  - Apply surface treatments
  - Structure in good condition
- Rehabilitation
  - Upgrading pavement structure



Micro surfacing

Key: proactive maintenance to preserve network

Surface treatments: maintenance

- Fog seal/rejuvenating fog seal
- Crack seal
- Chip seal/scrub seal
- Slurry seal/micro surfacing (slurry surfacing)
- Cape seal (chip/scrub + slurry surfacing)
- Ultra thin lift overlay (<1.0”)
- Ultra thin bonded wearing course (UTBWC)

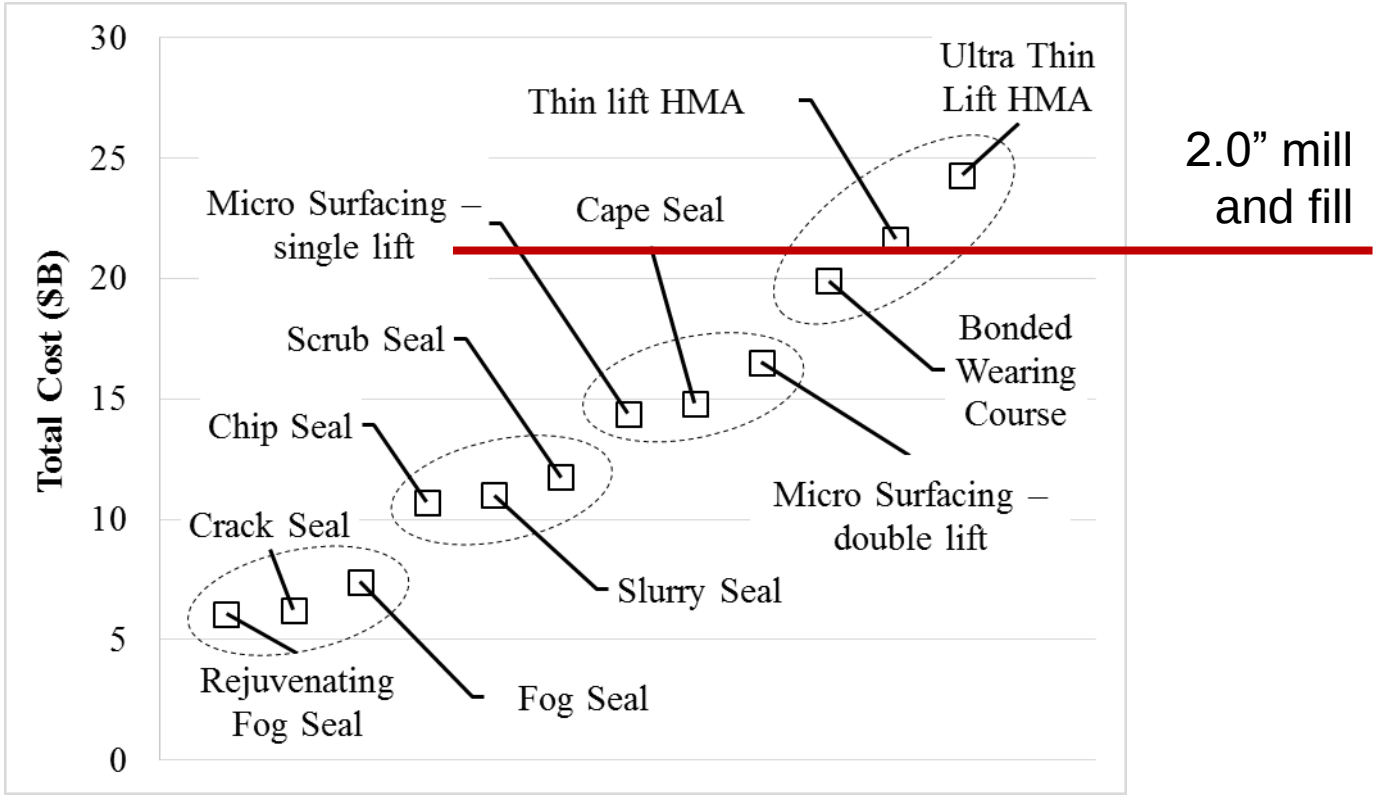
UTBWC

Why should we do this?

Roadresource.org

Cost savings: surface treatments

- Single treatment (LCCA)
  - Applied repeatedly over 50 years on entire ARDOT network
  - NOT recommended! Academic exercise
- 2.0” mill and fill: ~$21B

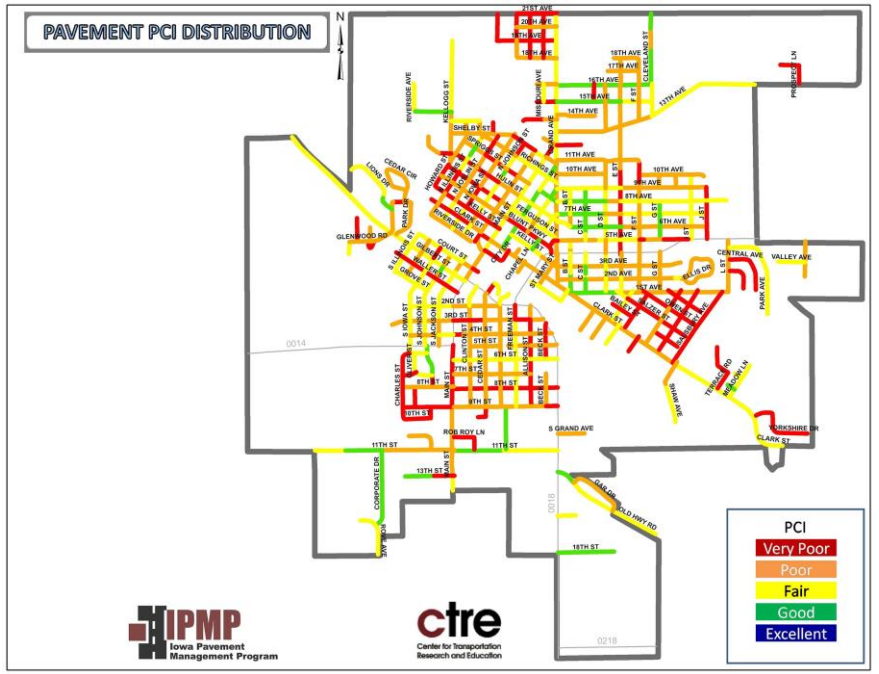


Cold In-place Recycling	Hot In-place Recycling	Full Depth Reclamation	Full depth remove and replace
~$31B	~$37B	~$39B	~$52B

What about pavement management systems?

What is a pavement management system?

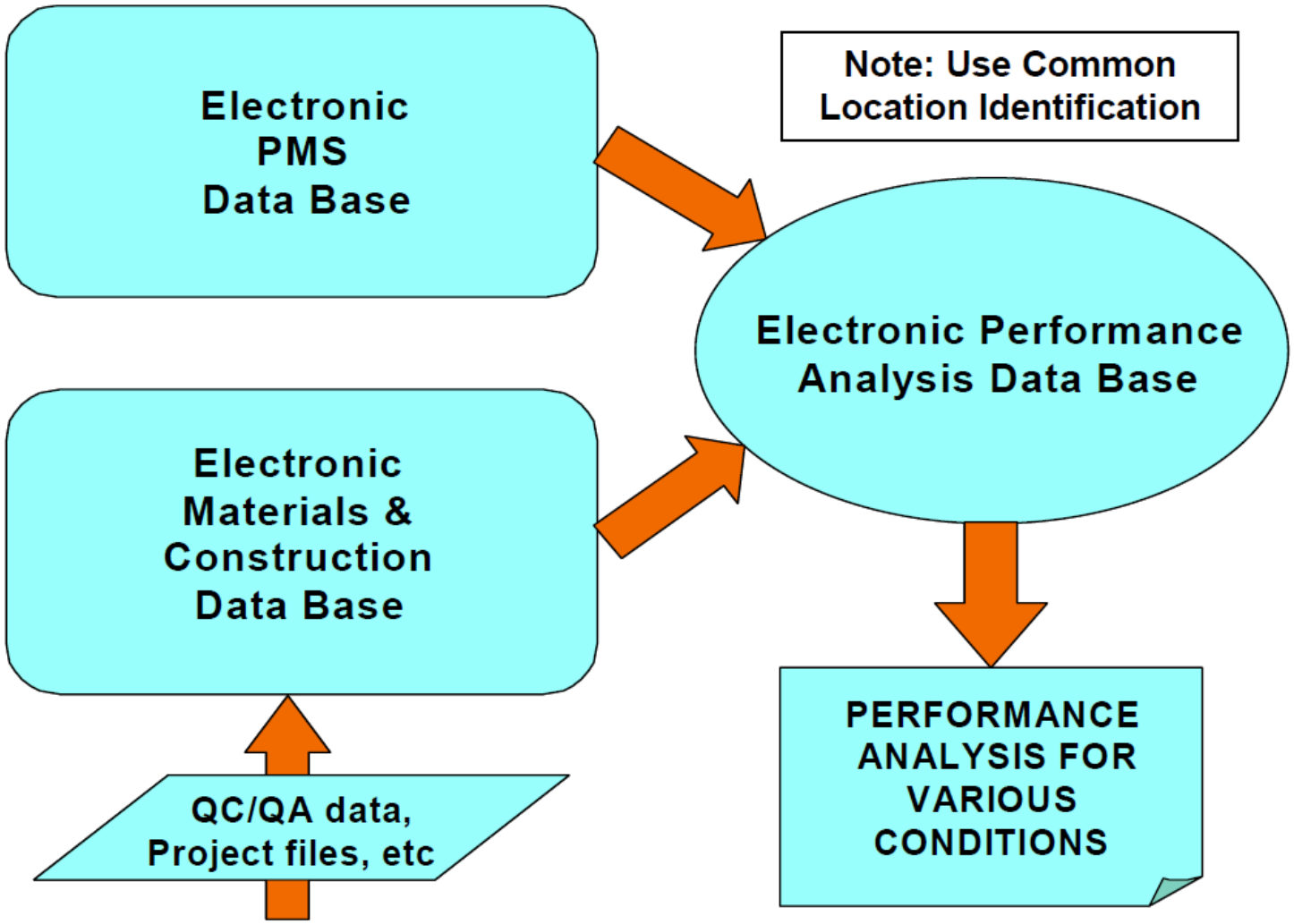
- A good system
  - Provides tools/methods to assist decision makers
  - Finds optimum strategies for providing, evaluating, maintaining pavements in a serviceable condition over a period of time
- Higher data quality/quantity build better models
- Data required
  - Materials/construction, traffic, routine maintenance, treatment history/costs, remaining service life, and individual distress



(ctre.iastate.edu)

Can we see a picture?

Pavement management system schematic



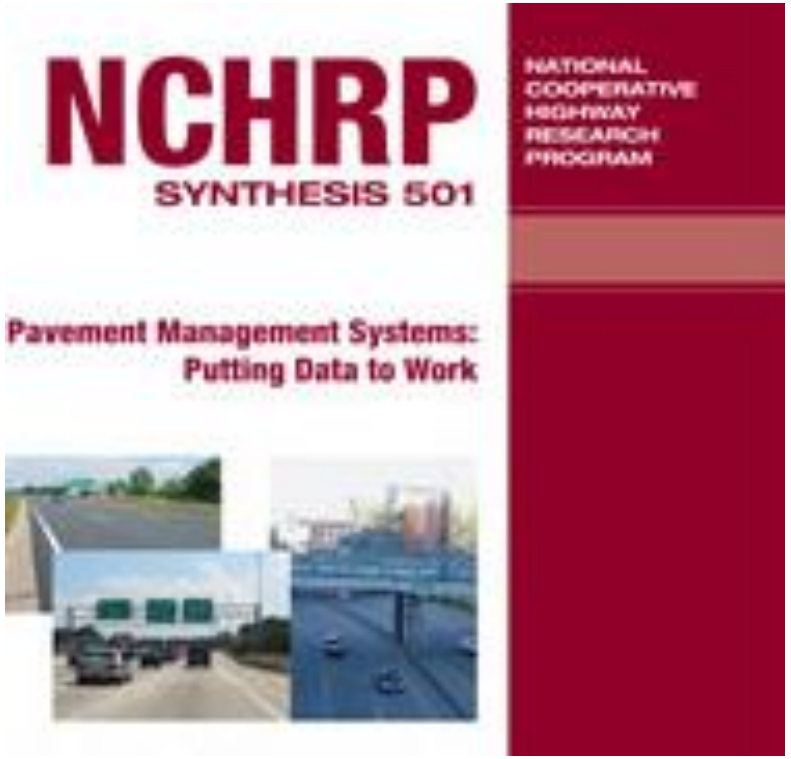
A flow chart of inputs and outputs through databases

Great resource? NCHRP!

(Hudson et al., 2002)

Pavement Management Systems: Putting Data to Work

- 2018 NCHRP Synthesis 501
- Synthesis focused on use of PMS for
  - Resource allocation
  - Treatment cost-effectiveness
  - Program development
  - Communication with stakeholders
- Three sources leveraged
  - Literature review
  - Survey to state transportation agencies
  - Five telephone conversations



(NCHRP, 2017)

Lots of good information available

Q: What data is available in your PMS?

Pavement condition information	100%
Individual distress values	92%
Traffic data	90%
Composite indices	85%
Individual indices	83%
Treatment history	77%
Treatment costs	77%

Routine maintenance (42%)
and remaining service life (31%)

Q: How are potential treatments identified?

Pavement condition	96%
Pavement type	87%
Traffic volumes or loads	78%
Pavement age	70%
Highway system	63%
Last treatment	59%

A total of 21 questions were asked → LOTS more in the synthesis

Synthesis also provided recommendations moving forward

Conclusions

- What is sustainability?
- Practice 1: the three pillars
  - Economic, environmental, social
- Practice 2: recycled/alternate materials
  - Asphalt binders and asphalt mixtures
- Practice 3: planning
  - Preservation, maintenance, rehabilitation
  - Pavement management systems

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Andrew F. Braham, Ph.D., P.E.
Professor
Civil Engineering

4190 Bell Engineering Center
Fayetteville, AR 72701
e-mail: afbraham@uark.edu

Phone: 479-575-6028
Fax: 479-575-7168
www.andrewbraham.com

Questions?

Thank you!

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