Arizona DOT Sustainable Transportation Program Linkage
ADOT’s pavement management contributes to sustainability by enhancing roadway safety, optimizing pavement life cycles to reduce costs, while considering the environmental impacts of construction and material usage.
Sustainable Pavement Defined

FHWA *TechBrief* on Pavement Sustainability (2014)

FHWA’s *Toward Sustainable Pavement Systems* (2015)

- FHWA defines a sustainable pavement as one which “achieves its specific engineering goal” (i.e., meeting accepted performance standards) while meeting “basic human needs,” using “resources effectively,” and preserving/restoring ecosystems.
- Pavement sustainability is meant to involve every phase of the pavement life cycle, including 1) materials production, 2) pavement design, 3) construction, 4) use, 5) preservation, maintenance, and rehabilitation, and 6) end-of-life management.
# ADOT Application Sustainability Matrix

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Description</th>
<th>Economic</th>
<th>Social</th>
<th>Environmental</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crack Filling</td>
<td>Placement of adhesive material</td>
<td>Life: Low</td>
<td>Aesthetics/Roughness</td>
<td>Low</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cost: Low</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Crack Sealing</td>
<td>Placement of adhesive material</td>
<td>Life: Low</td>
<td>Aesthetics/Roughness</td>
<td>Low</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cost: Low</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Asphalt Patching</td>
<td>Localized structural distress</td>
<td>Life: Medium/Low</td>
<td>Aesthetics/Roughness</td>
<td>Low Variable</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cost: Medium/Low</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fog/Seal Rejuvenators</td>
<td>Very light asphalt emulsion application</td>
<td>Life: Low</td>
<td>Improved Aesthetics</td>
<td>Medium Variable</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cost: Low</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chip Seal</td>
<td>Sprayed application/subsequent chips</td>
<td>Life: Medium/Low</td>
<td>Improved Friction/Roughness</td>
<td>Medium High</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cost: Medium/Low</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Slurry Seal</td>
<td>Mix of well-graded aggregate/emulsion</td>
<td>Life: Medium/Low</td>
<td>Aesthetics/Improved Friction</td>
<td>Medium</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cost: Medium/Low</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Microsurfacing</td>
<td>Crushed, well graded aggregate/emulsion/multiple course</td>
<td>Life: Medium/High</td>
<td>Aesthetics/Improved Friction</td>
<td>Medium Variable</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cost: Medium</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hot In-Place Recycling</td>
<td>Heat or mechanically loosening within top 2&quot;</td>
<td>Life: Medium/High</td>
<td>Aesthetics/Ride Quality/Friction</td>
<td>Medium High</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cost: Medium/High</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cold In-Place Recycling</td>
<td>Milling and sizing reclaimed asphalt pavement (RAP)</td>
<td>Life: Medium/High</td>
<td>Aesthetics/Ride Quality/Friction</td>
<td>Medium Variable</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cost: Medium</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
2019 ADOT Black & Green Program Goals

- Develop overall working group
- Continue documenting the 5-yr Construction Program Projects, Sub Program Surface Treatment / Pavement Condition activities
- Define the ADOT Materials sustainable program goals
- Begin documenting ADOT BMPs of each of the six (6) lifecycle phases in a single sustainable pavement systems framework
- Pilot a selection of suggested sustainable practices, innovations, and applications identified through the initial BMP process
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  - [https://www.fhwa.dot.gov/pavement/sustainability/articles/primer_on_pavement.cfm](https://www.fhwa.dot.gov/pavement/sustainability/articles/primer_on_pavement.cfm)
Life Cycle Assessment (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.

Life Cycle Cost Analysis (LCCA)
LCCA evaluates agency expenditures throughout the life of the expenditure, rather than only considering the initial investment. The goal of the LCCA is to promote the efficient use of materials and resources through the informed cost of using a product or implementing a program. LCCA can be viewed as the economic component of both LCA analysis and the three pillars of sustainability.
260 NA 302 F0038 01C Mainline Road – Overgaard
This is an EDC-4 Study Project divided into two sections which will receive two separate treatments. This is a life extension project and will be evaluated as a national and State performance level.

- MP 302.70 to MP 306.00 EB & WB Full Width
  Cape Seal: Pre-coated chip seal with TR+ and Type 3 Micro Surfacing
- MP 306.00 to MP 310.05 EB & WB Full Width
  Cape Seal: Pre-coated chip seal with TR+ and Type 3 Slurry

For this pilot it was determined that milling the ½” of AC could damage the existing pavement. The existing roadway surface will be cape seal treated in its “As-Is” condition.
Pavements, Materials, and Sustainability:

- Maximize performance and extend the life of our pavements to the furthest extent economically feasible while minimizing adverse impacts to both society and the environment.
- Driven by design, materials engineering, and the quality of both materials and construction with consideration for how these factors affect what exists beyond the pavement.
- Making our pavements sustainable (and preserving them) is the right thing to do and it is everyone's responsibility to participate in this effort.

How do we do it?
Materials

Background, Cont'd

- Very Good Condition
- Good Condition
- Fair Condition
- Poor Condition
- Very Poor Condition

Immediate Change in Condition

Target Condition

---

Control (Untreated Pavement)

Preserved Pavement

Improvement in Performance

Service Life Extension

Pavement Age

ADOT
Materials

• Performance Life
  • 20 years for new construction (typical, ADOT)
  • 10 years for overlay or mill and fill with 3 to 5 inches of new AC (ADOT)
  • Might increase thickness to accommodate increased traffic loading

• Preservation of Flexible AC Pavements
  • Drainage
  • Crack Fill
  • Fog Coat
  • Surface Treatment

• Maintenance Spots
  • Patch potholes
  • Shallow mill and fill or thin overlay with a cutback asphalt mix
Materials

- Pavements, Materials, and Sustainability:
  - Not discussed in detail in this presentation but worthy of mention:
    - Lower Permeability PCC for Bridge Decks / Fiber Reinforced PCC
    - RAP Chip Seals / Slurry Seals
    - Supplementary Cementitious Materials (Fly Ash, Silica Fume)
    - Recycled Concrete Aggregate
    - Balance Mix Design / Mixture Performance Testing
    - Non Destructive Testing

- Maximize performance and extend the life of our pavements to the furthest extent economically feasible while minimizing adverse impacts to both society and the environment.
• Perpetual Pavement: 50+ year design life without significant structural rehab or reconstruction.  
  – Asphalt Pavement Alliance (APA), 2002.

Wearing Surface (OGFC)

<table>
<thead>
<tr>
<th>Stable Subgrade</th>
<th>Aggregate Base</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Perpetual Section)</td>
<td>(Typical Section)</td>
</tr>
</tbody>
</table>

High Quality Aggregate Base

Binder Rich, Flexible AC

Asphaltic Concrete

High Modulus AC or SMA

Asphaltic Concrete
Materials

• High Quality Fractured Aggregate
  • Well established within ADOT specifications
  • Materials suppliers produce high quality aggregate

• Binder Selection (PG, PG+, TR+, CRA)
  • Adequately addressing both cold and warm temperatures
  • LTPPBind, PGSelect, local experience, traffic

• Improved Performance (Stability & Durability)
  • Increased Density & Improved Joint Density
  • Polymer / Rubber Modified Asphalt
  • Asphalt Rubber / Crumb Rubber Asphalt
  • Fiber Reinforced Asphalt
  • Reduced Moisture Susceptibility
  • Improved Construction Techniques

  • Mixture Performance Testing
Materials

Reclamation, Recycling, & Re-use of Existing Materials
Materials

• Pavements, Materials, and Sustainability:
  • Maximize performance and extend the life of our pavements to the furthest extent **economically** feasible while **minimizing** adverse impacts to both **society** and the **environment**.
Materials

• Reclaimed Asphalt Pavement (RAP)
  • Approaching 10 Million tons of RAP since 2009 (ADOT)
  • 15%, 20%, 25% (below upper 2 inches of AC)
  • LTPP SPS-10 Test Sections up to 30% (I-40 & I-8)
    • Included Warm Mix Technology

• Full Depth Reclamation

• Cold Recycling
  • Cold in-Place Recycling (CIR) since early ‘80s
    • 1.5 Million sq.yds. Since 2004 (rural, low volume roads)
  • 2018 - Revised & Updated Specification (includes CIR & CCPR)
    • Solventless Engineered Emulsion, Mix Design, Mineral Admix

• Hot in-Place Recycling
  • Over 1 Million sq.yds since 2004 (Repaving & Remixing)
Perpetual Pavement: How do we get there from where we are now?
Materials

- Mill and remove surface wearing coarse & upper AC.
- Fractionate and stockpile for use as cold recycled material (CCPR)
Materials

- Fractionate and stockpile for us as cold recycled material (CCPR)
- Full-depth reclamate and stabilize the remaining AC, Base, and Subgrade
Materials

• Fractionate and stockpile for us as cold recycled material (CCPR)
• Full-depth Reclamate and stabilize the remaining AC, Base, and Subgrade

Full-Depth Reclamated & Stabilized Section
(12 to 18 inches thick)
• Full-depth Reclamate and stabilize the remaining AC, Base, and Subgrade
• Place Cold Central Plant Recycled AC
Materials

- Full-depth Reclamate and stabilize the remaining AC, Base, and Subgrade
- Place Cold Central Plant Recycled AC
Materials

- Place Cold Central Plant Recycled AC
- Place 2 to 3 inches of Virgin AC mix (with RAP)
Materials

- Place Cold Central Plant Recycled AC
- Place 2 to 3 inches of Virgin AC mix (with RAP)
Materials

- Place 2 to 3 inches of Virgin AC mix (with RAP)
- Place Surface Wearing Course (ACFC, AR-ACFC, Chip Seal, Microsurfacing)

![Diagram of materials layers]

- Virgin SBS modified FRAC (with RAP)
- CCPR AC
- Full-Depth Reclamated & Stabilized Section
• Now that it’s built, how do we maintain it?
  • Minor pavement preservation (drainage, crack fill, fog seal)
Materials

- Minor pavement preservation activities
- Remove surface wearing coarse (if necessary)
Materials

- Minor pavement preservation activities
- Remove surface wearing coarse (if necessary)
- Hot in-Place Recycle the upper 1.5 to 2 inches of pavement
Materials

- Remove surface wearing coarse (if necessary)
- Hot in-Place Recycle upper 1.5 to 2 inches of pavement
Materials

- Hot in-Place Recycle upper 1.5 to 2 inches of existing AC
- Place additional Virgin AC if necessary (Repaving) and replace surface wearing coarse
Materials

• Repeat HIR process 1 to 2 additional times
  • May require addition of virgin materials/rejuvenators
  • 8-12 year life expectancy
Materials

- What is the treatment after HIR is no longer effective?
• Cold in-Place Recycle upper 4 inches
Materials

- Cold in-Place Recycle upper 4 inches
- Place 2-3 inch overlay of Virgin AC (with RAP)
• Place 2-3 inch overlay of Virgin AC (with RAP)
Materials

- Place Surface Wearing Course

VIRGIN AC (with RAP)

CIPP R AC

CIPP R AC

Full-Depth Reclamated & Stabilized Section
• Performance Life (initial 15 years before significant surface rehab)
  • HIR after 15 years (year 15)
  • HIR after another 10 years (year 25)
  • CIR after another 8 years (year 33)
  • Significant Recon./Rehab. after another 12 years (year 45)
Materials

- Materials Consumed
  - Emulsion / Cement for FDR and CCPR
  - Virgin Aggregate and Binder for High Modulus AC Overlay
  - Virgin Aggregate and Binder for Surface Wearing Course
  - Virgin Binder for HIR (Virgin Aggregate if Repaving)
  - Emulsion with Cement/Lime for CIR
  - Virgin Aggregate and Binder for Overlay and Wearing Courses
Materials

SUBGRADE ACCEPTANCE CHART

Plasticity Index

% Passing No. 200 Sieve

UNACCEPTABLE

ACCEPTABLE

Design R-Value = 20
Construction Control R-Value = 20
Materials

SUBGRADE ACCEPTANCE CHART
IMPROVEMENT

Plasticity Index

% Passing No. 200 Sieve

BITUMEN

LIME

CEMENT

UNACCEPTABLE

ACCEPTABLE

Design R-Value = 20
Construction Control R-Value = 20
I-40 Devil Dog (PCCP)
- Geogrid
- Existing PCCP crushed/re-used for Aggregate Drainage Layer
- Asphalt Base Mix

I-40 Cataract Lake (AC)
- Cement Treated Cinders w/Microcracking
- RAP (up to 25% in AC) with some WMA
- Polymer Modified Asphalt in upper 2 inches of AC
- Intelligent Compaction

I-17 Coconino County Line (AC)
- Geogrid Reinforced reclaimed Cinders/RAP Base
- Intelligent Compaction

SR89A Cottonwood to Sedona
- Fiber Reinforced AC
Materials

- Pavement Preservation & Recycling Alliance (PPRA)
  - RoadResource.org

- National Center for Pavement Preservation (NCPP)
  - PavementPreservation.org

- Asphalt Recycling & Reclaiming Association (ARRA)
  - AARA.org

- FHWA, NCAT, Asphalt Institute, State & Local DOTs
One final area to be aware of – FHWA [https://www.fhwa.dot.gov/pavement/sustainability/hif17029.pdf](https://www.fhwa.dot.gov/pavement/sustainability/hif17029.pdf)

FHWA project to pilot, begin educating, and develop future guidance for EPDs. In life cycle assessment, an EPD is a standardized way of quantifying the environmental impact of a product or system. In short, is an effort with stakeholders to develop standard product category rules so LCAs between products and system approaches are comparable.

FHWA Environmental Product Declarations And Product Category Rules [https://www.fhwa.dot.gov/pavement/sustainability/articles/environmental.cfm](https://www.fhwa.dot.gov/pavement/sustainability/articles/environmental.cfm)
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Thank you

Steven Olmsted

Nye McCarty

Kevin Robertson

Paul Burch